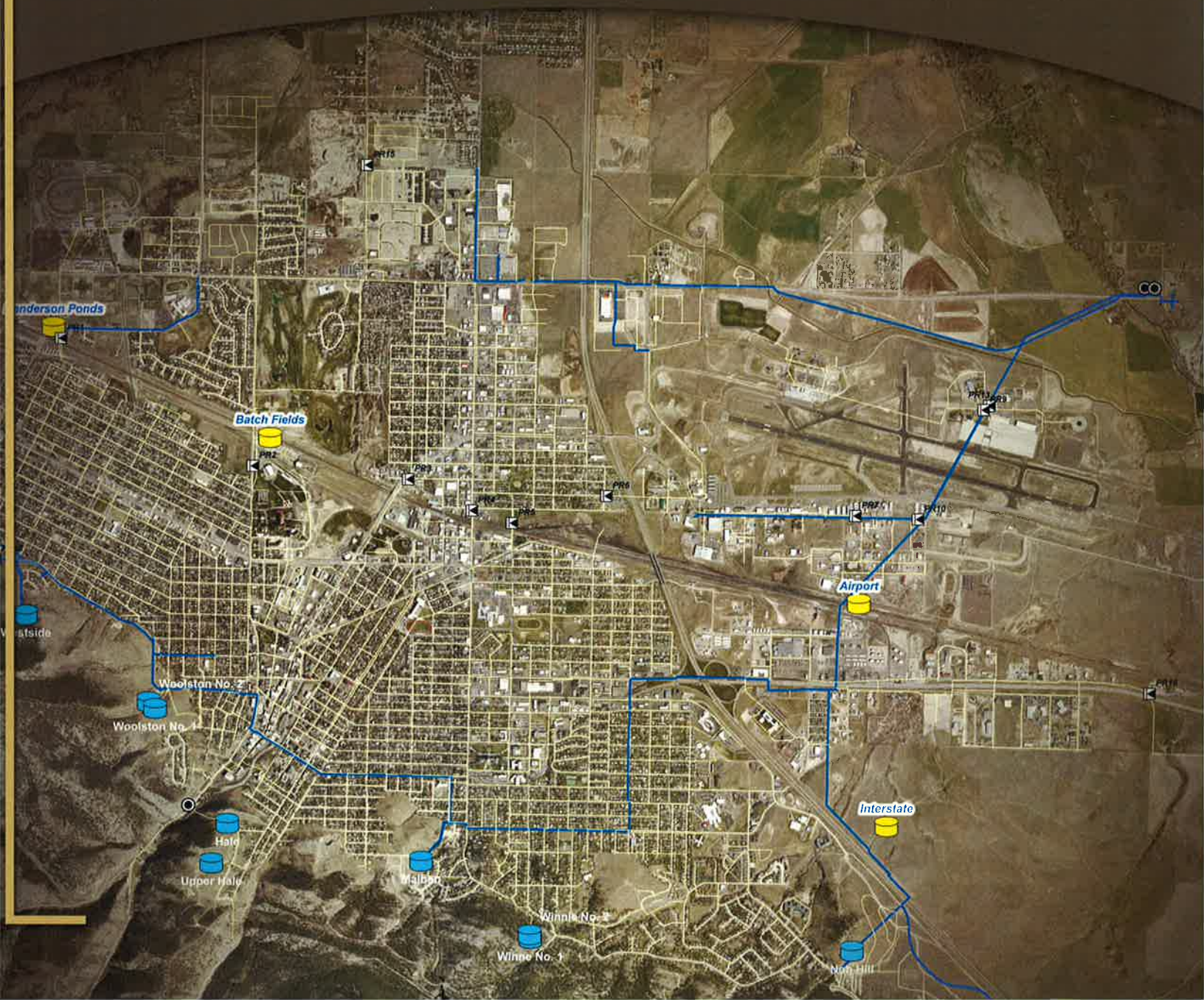
City of Helena

Water Facility Plan Update

December 2011



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Chapter 1: Executive Summary

Introduction

The City of Helena completed a comprehensive water facility plan in 2005. The plan evaluated supply and treatment facilities and a hydraulic model was developed for the distribution system. The primary focus of the 2005 Helena Water Facility Plan was on treatment facilities and reversing the roles of the Ten Mile and Missouri River Water Treatment Plants. In 2009 the City undertook the task of creating an update to the 2005 Water Facility Plan with a focus on the transmission, distribution and storage systems.

Population and Planning Areas

Since completion of the 2005 Plan, the water system has expanded to the Valley, and east of the Winne Zone (west of Interstate 15). Population projections used for the facility plan update matched the projections that were used for the 2005 Plan. Population projections are summarized in Table 1-1.

Table 1-1 - Population Projections[1]

	2004	2025	Buildout
City of Helena	31,005	35,986	40,493
Central Valley	330	9,670	15,166
North Valley	0	853	4,588
West Side	540	3,300	4,060
Fort Harrison	162	212	258

1. Population projections based on the 1998 Helena Area Wastewater Treatment Plan

Production and Water Demand

Historic Usage

Average annual water use observed in 2009 did not differ significantly from findings of the 2005 Plan. Therefore, per capita demands and maximum to average day ratios from the Plan were utilized for this Update as well. Current research indicates that per capita water demands are decreasing. This is largely due to the increased usage of water conserving fixtures within homes, improved irrigation methods and a conservation mindset (AWWA Journal, *Residential Water Use Trends in North America,* Volume 103, Number 2, February 2011). The City observed a much lower per capita demand in 2009 compared to previous years. However, until a more pronounced trend is observed in Helena, the City's water use projections will be based on historical per capita demands. Table 1-2 provides a summary of historical water production, population and per capita demand.

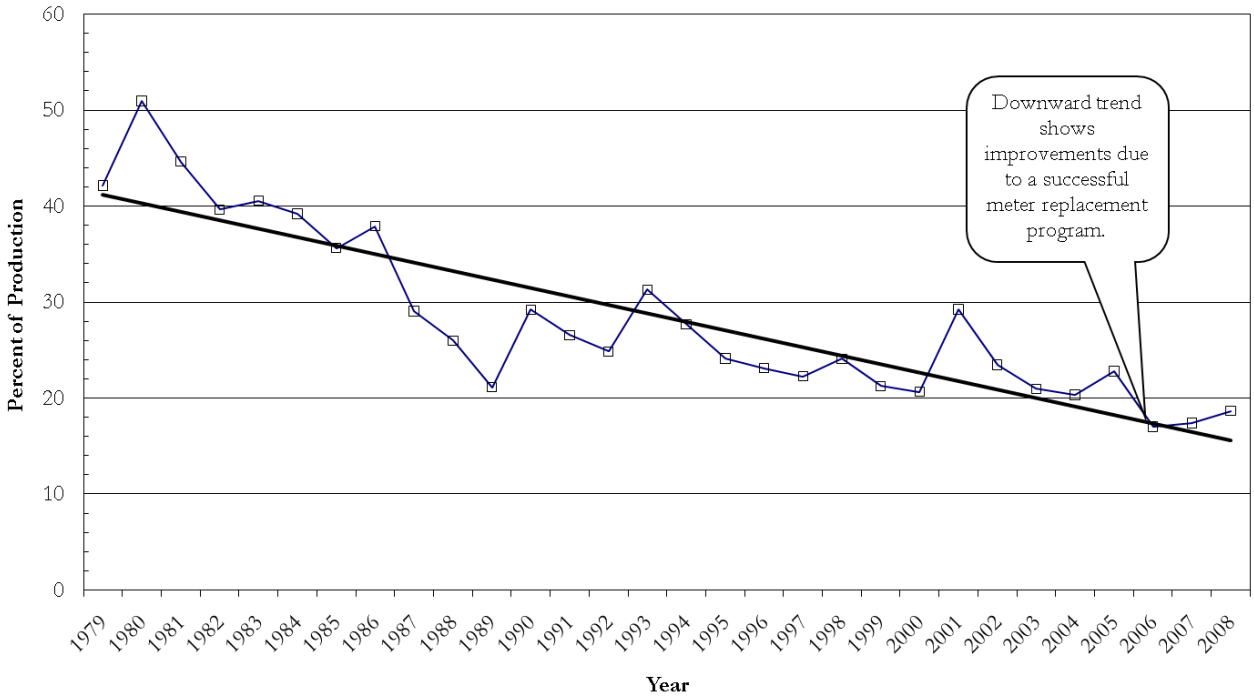
Table 1-2 - Historical Water Production, Population and Per Capita Demand

Year	Population	Average Annual Production (mgd)	Maximum Daily Production (mgd)	Average Per Capita Demand (gpcd)	Maximum Day to Average Day Ratio	Maximum Month Production
1999	29,968	5.1	12.7	171	2.5	August
2000	30,208	5.8	12.3	192	2.1	July
2001	30,578	5.5	11.6	179	2.1	August
2002	30,592	4.9	11.7	157	2.4	July
2003	31,330	5.5	15.7	176	2.9	August
Average		***5.4***	***12.8***	***175***	***2.4***	
2009	35,714	5.3	12.1	147	2.3	July

Unaccounted for Water

Unaccounted for water (UAW) use occurs within all water systems and is calculated as the difference between the quantity of water delivered into the distribution system as measured at the treatment plants and the total amount of all water metered to be used by customers. UAW encompasses leaking in the distribution system, conveyance losses, main flushing, fire hydrant flow testing, inaccurate metering and unauthorized connections or use. The City of Helena's historical UAW trend can be seen in Figure 1-1.

Figure 1-1 - Unaccounted for Water 1979 - 2008



The figure shows a general downward trend in the percentage of water that is unaccounted for, indicating that water loss is gradually being curtailed. In 2006, the City undertook a meter replacement program. When the replacement program was complete, UAW was anticipated to drop 5 percentage points to approximately 18 percent. Statistics indicate that the meter replacement program was a success.

Future Demand

Estimating future population and demand is crucial in planning for water system development. Table 1-3 and Table 1-4 provide a summary of projected 2025 and buildout demands based on the population projections and per capita demand data presented above.

Table 1-3 - 2025 Water Demands for City of Helena Service Area

Planning Area	2025 Population	Average Annual (mgd)	Maximum Day (mgd)	Peak Hour (mgd)
City of Helena (City Limits)	35,986	6.3	15.1	22.0
Central Valley	9,670	1.7	4.1	5.9
North Valley	853	0.1	0.4	0.5
West Side	3,300	0.6	1.4	2.0
Fort Harrison	212	0.0	0.1	0.1
Total	**50,021**	**8.8**	**21.0**	**30.6**

Table 1-4 - Buildout Water Demands for City of Helena Service Area

Planning Area	Buildout Population	Average Annual (mgd)	Maximum Day (mgd)	Peak Hour (mgd)
City of Helena (City Limits)	40,493	7.1	17.0	24.8
Central Valley	15,166	2.7	6.4	9.3
North Valley	4,588	0.8	1.9	2.8
West Side	4,060	0.7	1.7	2.5
Fort Harrison	258	0.0	0.1	0.2
Total	**64,565**	**11.3**	**27.1**	**39.5**

It is estimated that the City of Helena service area will include approximately 50,000 people in 2025. In 2025, the average annual water required will be 8.7 MGD. In 2045, the service area population is estimated to be close to 65,000, and the average daily demand will be 11.3 MGD.

Distribution System Analysis

Analysis of the City's distribution system was completed using an updated version of the hydraulic water model. The analysis considered improvements that have been completed since the 2005 Plan and included pressure, fire flow, and water quality.

Distribution System Update

Many improvements have been made to the City of Helena's Distribution System since the 2005 Plan including finished water storage and pumping improvements, pressure zone re-configurations, distribution pumping and storage modifications and piping improvements.

Pumping and Storage

In 2008, improvements were made to the Missouri River Treatment Plant. These improvements included:

- 1.5 MG clearwell
- A new pumping station providing 12.6 MGD of pumping capacity for the High Zone Service Area, expandable to 16.8 MGD.
- Replacement of existing high pressure zone high service pumping with transfer pumps.
- A new variable frequency drive (VFD) was added to one low pressure zone high service pump.
- Backup power capability to provide power to one high service pump, one transfer pump, and miscellaneous electrical demands.

Additionally, a new storage tank was constructed on the Westside and improvements were made to the Forrest Estates Pump Station.

Pressure Zones

The Forrest Estates pressure zone was combined into a larger pressure zone known as Westside. Additionally, the Upper Malben-Wooston Zone in the vicinity of the Airport was modified to include an Airport pressure zone.

Distribution System

Major improvements to the distribution system included:

- Slip lining of 20" Steel in Airport Road
- Laurel Street main Replacements
- Leslie Avenue main replacements
- Mountain View Meadows water main extension
- Lower Malben-Woolston Zone water main extensions including areas north and south of Custer Ave.
- Reber Phase II Subdivision south of Le Grande Cannon Boulevard

Distribution System Evaluation

Hydraulic Model Update

As part of the Water Facility Plan Update, the system hydraulic model was updated. The update included:

- Conversion of the model from Bentley WaterCAD to MWH Soft InfoWater.
- Addition of missing elements.
- Update of system demands to 2009.
- GIS update of the physical system.
- Demand allocation by parcel and City consumption records for maximum and minimum demand conditions with 2010 demand.

A detailed evaluation of the Helena water system was completed utilizing the updated InfoWater hydraulic model. The evaluation included analysis of pressure and fire flow under max day demand conditions for current and 2025 demands. It also included water quality analysis under average day demand conditions for the same planning periods and predicted populations.

Pressure Analysis

A simulation of the maximum day demand was run for the current and 2025 population conditions. Nodes experiencing pressures below 30 psi were confined to the higher pressure zones within the City of Helena specifically in the vicinity of the storage reservoirs. The analysis of the 2025 conditions did not yield a significantly different output from the current conditions with the exception of 13 additional low pressure nodes mostly within the vicinity of Le Grande Cannon.

Fire Flow Analysis

For planning-level analyses, the City of Helena requires a minimum amount of flow to be available depending on the type of land use at a given location. Table 1-5 indicates fire flow requirements based on land use type.

Table 1-5 - Fire Flow Criteria Based on Land Use Type

Land Use	Required Fire Flow (gpm)
Residential	1,750
Office/Business	1,750
School	1,750
Commercial	1,750
Light Manufacturing	3,750
Industrial	3,750

The available fire flow was calculated at each node in the distribution system under maximum day demand conditions while maintaining a minimum zone pressure of 20 psi at the location where the fire flow was being calculated. To determine where fire flow deficiencies existed, the available fire flow for each node was compared to the fire flow required based on the land use classification. Table 1-6 provides a summary of the nodes where planning level fire flow requirements were not satisfied according to land use.

Table 1-6 - Percent Deficient Nodes According to Fire Flow Requirement

Land Use	Fire Flow Requirement	Total Number of Nodes	Fire Flow Deficiencies	
			No. of Nodes	Percent of Total
Residential/Office /Business/Commercial /School	1,750	3,808	1,295	34 %
Heavy Commercial/Light Manufacturing/Airport	3,750	312	234	75 %
Total		**4,120**	**1,529**	**37 %**

Table 1-7 provides a summary of deficient nodes by pressure zone.

Table 1-7 - Percent Deficient Nodes According to Pressure Zone

Pressure Zone	Total Number of Nodes	Fire Flow Deficiencies	
		No. of Nodes	Percent of Total
Lower Malben Woolston	1,217	253	21 %
Upper Malben Woolston	2,202	737	33 %
Winne	380	85	22 %
Westside	105	16	15 %
Reeders Village	15	0	0 %
Hale	143	66	46 %
Upper Hale	13	4	31 %
Total	**4,075**	**1,161**	**29 %**

As indicated in the table, approximately 29% of the nodes in the system are deficient with the largest percentage of fire flow deficiencies occurring in the heavy commercial/light manufacturing/airport land use categories.

Some of the deficiencies are located in older portions of town which have a large percentage of older pipes with low roughness coefficients (less than 60), small pipe diameters and dead-end lines.

The 2025 fire flow model was evaluated with settings that were slightly different than that of the existing system. The primary difference between the two analyses was the operation of the Missouri River Water Treatment Low Zone Pump Station and the existence of a Low Zone Reservoir. The 2025 analysis did not produce significantly different results when compared to that of the existing system.

Water Quality Analysis

Water quality was evaluated based on estimated water age using the hydraulic water model. Water quality analysis at Current Average Day demands resulted in fair quality water over the majority of the system, and hot spots located in the upper reaches of the system. The areas with the highest water age include the Winne and Upper Hale pressure zones with ages on the order of 290 and 300 hours, respectively. System water quality is on the average of 10 days old.

Water quality analysis at 2025 Average Day demands resulted in improvements in water age in the system, corresponding largely to an increase in average day demands. System average decreases from 240 hours (10 days) at current average day demands to 144 hours (6 days) at 2025 average day demands.

Recommended Improvements

The distribution system piping analysis evaluated improvements related to redundancy, reduction in headloss, improvement to fire flow, interconnection of pressure zones and pump stations to improve operability and service, major waterline extensions and rehabilitation projects.

Recommended projects include general recommendations to improve redundancy and operability of the existing system, fire flow improvements, pipe extensions to serve growth, and renewal and replacement.

Tenmile Transmission Main Alternatives Evaluation

Treated water is conveyed from the Tenmile Treatment Plant (TMTP) to the City of Helena's storage and distribution system through approximately 6.4 miles of various sized pipes that, for the most part, parallel Highway 12. The conveyance system has limited capacity to deliver treated water to the system. The TMTP has a treatment capacity of 8.5 MGD but only 7.0 to 7.5 MGD can be conveyed through the current transmission main configuration. Multiple pipe failures have occurred on the older sections of pipe and they are at the end of their useful life. In addition, existing control valves are ineffective causing water quality issues, especially when bringing the TMTP on line after it has been out of service.

Several options were evaluated for renewal and replacement of the Tenmile transmission main. Options took into consideration the need to increase transmission main capacity and improve flow

control. Options included slip lining and pipe bursting existing piping and complete pipe replacement. The hydraulic model was used to evaluate alternatives and compare the capacity of each.

The least cost overall alternative is replacing the existing older segments of pipe with a new 36-inch ductile iron pipe. This alternative also results in the highest system capacity.

Pressure Zone and Storage Analysis

The City's distribution system consists of two large pressure zones, the Upper and Lower Malben-Woolston Zones, and five smaller zones, the Winne, Hale, Upper Hale, Reeder's Village and Westside Zones. There are nine water storage reservoirs and two clearwells within the City of Helena water distribution system: Nob Hill, Woolston No. 1, Woolston No. 2, Malben, Winne No. 1, Winne No. 2, Hale, Upper Hale, Westside, Ten Mile Treatment Plant Clearwell, and Missouri River Treatment Plant Clearwell. There are eight pumping stations located within the City of Helena water distribution system.

The Water Facility Plan update includes a detailed evaluation of alternatives for: Constructing a lower Malben-Woolston Zone storage tank; existing tank optimization; improving the Fort Harrison water system connection to the City system; Lower Malben-Woolston Zone pumping; and pressure zone reconfiguration.

Lower Malben-Woolston Tank

The Lower Malben-Woolston and Valley Zones need 4.03 MG of storage to meet projected 2025 demands if the excess capacity of the Upper Malben-Woolston Zone is taken into consideration. The storage requirements of these zones can be met by either improving storage capacity in the Upper Malben-Woolston Zone or by constructing new storage in the Lower Malben-Woolston and Valley Zones or a combination of both. If the TMTP clearwell volume can be maximized, the required volume in the Lower Malben-Woolston and Valley Zones could be reduced to 3.0 MG. Maximizing the TMTP clearwell volume however, would not improve low zone pressure conditions.

Feasible sites for locating a Lower Malben-Woolston Reservoir and Pumping Station were evaluated. Feasible sites included the Henderson Stormwater Ponds, Batch Fields, City owned property near the airport, the wastewater treatment plant (WWTP) site, and property adjacent to I-15 southeast of the intersection of I-15 and Highway 12. The airport and WWTP sites were fatally flawed and thus not carried forward in the evaluation.

Adding a Lower Malben-Wooston Zone tank significantly improve the pressure conditions in the low zone. The average pressure in the low zone would be reduced from 110 psi to 75 psi. Maximum system pressures would see similar reductions. System pressure throughout most of the low zone would be between 30 and 90 psi. Maximum pressures would exceed 160 psi but only on the MRTP high zone transmission main. Adding a high zone pumping station at the I-15 tank location would eliminate this high pressure condition.

Table 1-8 provides a comparison of reservoir alternative costs including connector piping, pumping, and pipe optimization components.

Table 1-8 - Reservoir Alternative Cost Comparison Summary

Project Element	Henderson Ponds	Batch Fields	I-15
Tank	$4,680,000	$4,360,000	$2,730,000
LZ to HZ Booster Pumping	N/A	N/A	$800,000
MRTP HZ Pumping Modifications	N/A	N/A	$50,000
Connector Piping	$100,000	$100,000	$1,110,000
Base Project Cost	**$4,780,000**	**$4,460,000**	**$4,690,000**
Pipe Optimization	$2,100,000	$3,200,000	$2,900,000
West Side LZ to HZ Booster PS	$600,000	$600,000	$800,000
Total Project Cost	**$7,480,000**	**$8,260,000**	**$8,390,000**

Each reservoir site was evaluated on a scale of 1-10, ten being the best and one being the worst for each of the evaluation criteria including system pressure, fire flow, water age/quality, energy usage, property ownership, airport impact, cost, constructability, compatibility with other infrastructure, compatibility with growth, security, community acceptance, impact to adjacent property, and maintenance. Table 1-9 provides a summary of the evaluation.

Table 1-9 - Reservoir Evaluation Criteria Comparison

Reservoir Site	Pressure	Fire Flow	Water Age/Quality	Energy Usage	Property Ownership	Airport Impact	Initial Capital Cost	Total Project Cost	Constructability	Compatibility with other Infrastructure	Compatibility with Growth	Security	Community Acceptance	Impact to adjacent Property	Maintenance	**Total Points**
Henderson Ponds	7	8	5	5	6	9	7	8	7	8	7	8	5	4	6	**100**
Batch Fields	7	8	5	5	9	8	9	7	8	7	8	8	6	5	6	**106**
I-15	9	7	5	6	6	10	8	6	9	6	6	7	8	5	8	**106**

The Lower zone tank evaluation concluded that constructing a tank at the Batch Fields, I-15, and Henderson sites are all viable options with the Batch Fields and I-15 sites ranking the highest when all parameters were considered. Constructing a low zone tank would significantly reduce low zone system pressures and provide some energy savings.

Growth has slowed considerably in the Helena valley since the 2005 Water Facility Plan was completed and the demand projections for 2025 were made. It is reasonable to believe that the 2025 demand projections may not be realized until sometime beyond 2025. Taking the current economy

and growth rates into consideration, it is recommended that the City consider building two 1.5 MG tanks instead of a single 3.0 MG tank. The analysis shows that additional storage will be required by approximately 2016 under the current growth projections. A 1.5 MG tank would provide adequate capacity until approximately 2025 if the Valley Zone does not grow and connect to the City's system. The City should continue to assess development patterns and property availability as a decision is made as to the best location and size of the Low Zone tank. Table 1-10 summarizes the cost of the Batch Fields and I-15 tank alternatives if a 1.5 MG tank is constructed.

Table 1-10 – Low Zone Reservoir Cost Summary

Project Element	Batch Fields	I-15
Tank	$2,860,000	$1,500,000
LZ to HZ Booster Pumping	N/A	$800,000
MRTP HZ Pumping Modifications	N/A	$50,000
Connector Piping	$100,000	$1,110,000
Base Project Cost	**$2,960,000**	**$3,460,000**
Pipe Optimization	$3,200,000	$2,900,000
West Side LZ to HZ Booster PS	$600,000	$800,000
Total Project Cost	**$6,760,000**	**$7,160,000**

It should be noted that development in the area of the I-15 tank location could provide the opportunity for a portion of the interconnecting piping cost to be shared by development.

Existing Tank Optimization

Woolston Tanks

The Woolston reservoirs have available storage in emergency situations when the hydraulic grade line drops low enough which typically doesn't happen until flow from the TMTP is less than 2.5 MGD. Under predicted demand conditions, it is not feasible to limit the TMTP operation to 2 MGD on a regular basis. Improvements necessary to make the Woolston storage volume are expensive or result in unacceptable water quality issues. The evaluation showed that it would be more cost effective to make improvements to the TMTP backwash pumping and construct additional volume in the Lower Malben-Woolston Zone.

Malben Tank

The Malben reservoir is a 4.0 MG tank of which 2.7 MG is active. The 2005 Water Facility Plan evaluated options for achieving full utilization of the Malben reservoir and thus adding 1.3 MG of storage to the Upper Malben-Woolston Pressure Zone. Improvement options included constructing a new Dalhausen Pump Station and back-up power. If additional storage is constructed in the Lower-Malben Zone, additional storage is not needed at the Malben reservoir. It is more efficient to construct storage in the Lower Malben-Woolston zone so it is not recommended that a new Dalhausen Pump Station be constructed, however: adding backup power to the existing pump station and increasing firm pumping capacity would improve reliability of the system to meet peak hour demand in the Winne Zone.

Hale Tank

The Hale Zone has a single source of supply, the Eureka source, which has a difficult time keeping up with demands during peak demand periods. It is recommended that the Hale Zone be connected to the Winne Zone and in time to the Upper Malben-Woolston Zone and Reeder's Village for redundancy and energy efficiency.

Westside Tank

The Westside storage tank and Forrest Estates pump station modifications were constructed and put into service in 2010. While the improvements have improved pressures and brought fire flow availabilities into compliance, the large volume of storage and few connections is creating a water quality issue. It is recommended that Reeder's Village be connected to the Westside pressure zone to increase demand on the tank.

Fort Harrison

The Fort Harrison water system is a consecutive system located at 3687 Veterans Drive in the northwestern portion of Helena. The system serves the Veterans Administration (VA) facility, Montana Army National Guard (Fort Harrison), and other branches of the federal government including the Naval Reserve Center and US Property and Fiscal offices. The system is master metered off of the City of Helena water system in two locations.

The Fort Harrison distribution system was evaluated in light of the City of Helena's capabilities to serve the area. This included evaluating different plant operating scenarios and at different demand needs, including fire flow requirements. The evaluation also included relocating the connection to the City's system to the Lower Malben-Woolston Zone. The evaluation showed that the City's system cannot keep up with max day demand with the MRTP operating alone. It also showed that the hydraulic grade line of the Lower Malben-Woolston Pressure Zone is well below the minimum level of the VA's existing tank.

Based on the analysis the following improvements are recommended:

- Replace the existing backflow preventer with a 10-inch model.
- Expand the operating range of the existing tank to 6 or 7 feet.
- If the City plans on operating the MRTP alone, a booster pumping station should be constructed.

Lower Malben-Woolston Zone Pumping

The Lower Malben-Woolston Pumping Station pumps water from the MRTP to the Lower Malben-Woolston pressure zone. Since there isn't a tank in the low zone, the pumps pump against a closed system. There is a pressure relief valve on the pumping system that relieves water back to the clearwell at discharge pressures above 170 psi.

Historically, during current minimum day demand periods, water was continuously recycled back to the clearwell and system pressures were in excess of 120 psi. The hydraulic model was utilized to evaluate alternatives for optimizing low zone pumping. The evaluation showed that if a VFD was

added to the smallest booster pump, it could match the minimum day demand with no recycle to the clearwell and significantly lower system pressures could be maintained. A VFD was added and a significant improvement in Low Zone pumping efficiency and pressure was realized.

Pressure Zone Reconfiguration

The City of Helena experiences high pressures throughout a large portion of the distribution system generally in the Upper Malben-Woolston pressure zone at its interface with the Lower Malben-Woolston pressure zone. In order to lower these pressures, the boundary between the Upper and Lower Malben-Woolston Zones would need to be reconfigured. The hydraulic model was utilized to evaluate moving the pressure zone boundary so that system pressures would never exceed 135 psi. Based on the evaluation, the boundary would move south to approximately Euclid and Montana Avenues.

Treatment Plant Analysis and Comprehensive Performance Evaluation

Comprehensive Performance Evaluation

A Comprehensive Performance Evaluation (CPE) of the City of Helena's Missouri River Water Treatment plant and Tenmile Water Treatment Plant was performed in 2009. The Water Facility Plan Update includes a summary of the evaluation and resulting recommendations.

Tenmile Maintenance Flow Evaluation

The Montana Fish Wildlife and Parks requested the City of Helena provide maintenance flow in the Tenmile Creek drainage for preservation of trout. The Tenmile Creek drainage provides the raw water supply for the Tenmile Water Treatment Plant. The Tenmile Creek drainage supply capacity was evaluated against current and future demand to determine the level of its ability to meet an in stream maintenance flow of 1 CFS and 4 CFS as requested by Montana Fish Wildlife and Parks.

The evaluation showed that on the average, for the period evaluated (2000 – 2009) a 1 CFS maintenance flow could be maintained under current demand conditions and a 4 CFS maintenance flow could be maintained except for the month of August. There were occasions during that period that a 1 CFS and a 4 CFS maintenance flow couldn't be maintained during peak day demand conditions. The analysis showed that it is not possible to maintain a 1 CFS or a 4 CFS maintenance flow under predicted 2025 peak day demand conditions but the system could likely meet the maintenance flow requirements under average day demand conditions.

Tenmile Treatment Plant Copper and Zinc Analysis

Bench scale analysis was performed on Tenmile Water Treatment Plant raw water to evaluate the use of alterative polymers and coagulants for optimization of zinc, copper, and TOC removal. The goal of the analysis was to evaluate alternatives for minimizing the Tenmile's contribution of copper and zinc to the City's wastewater system. TTP effluent copper concentrations are quite low and it was determined that little improvement could be made by improving copper removal at the TTP. Conversely, TTP effluent zinc concentrations are well above the MPDES discharge permit limits and it

may be possible to significantly reduce the contribution of zinc to the wastewater treatment plant by improving zinc removal at the TTP.

Bench scale analysis was completed on TTP raw water samples. The analysis showed that zinc levels could be significantly reduced by raising pH and optimizing alum and polymer addition. It is recommended that full scale testing be completed at the TTP to further determine the effectiveness of zinc removal under actual field conditions.

Recommended Plan

The City of Helena has limited resources to invest in water infrastructure, making prioritization of capital improvement projects a necessity. Multiple criteria govern the prioritization of capital improvement projects such as fire protection, protection of public health, distribution system reliability, and regulatory compliance.

Analysis performed on the water system concluded that improvements are needed to the system to improve fire flow, pressure, and water quality to better serve existing customers. In addition, existing system components must be replaced once they reach the end of their useful life. Typically, replacing about 2% of the total system per year is an adequate goal to achieve a recommenced 50-year replacement cycle. It may be more appropriate, based on current historical service life, to replace distribution system piping on a 100-year cycle, or 1% per year. The City of Helena's water distribution system consists of approximately 1.2 million feet of pipe. A 100-year replacement cycle equates to replacing 12,000 lineal feet per year. The City currently replaces approximately ½% per year or 6,000 lineal feet of pipe.

The water system analysis evaluated improvements related to redundancy, reduction in headloss, improvement to fire flow, interconnection of pressure zones and pump stations to improve operability and service, major waterline extensions, rehabilitation projects, and storage improvements. Recommendations for capital projects were split into two categories. The first category includes storage, transmission, and pumping system improvements that are required to modify pressure zones to improve system pressure conditions, meet storage demand, and provide reliable transmission of drinking water throughout the system. These projects are summarized in Table 1-10.

Table 1-10 - Summary of Recommended Storage, Transmission, and Pumping Capital Projects

Project	Project Type	Rank	Triggers	Estimate of Probable Project Cost
Lower Malben-Woolston Zone Pumping Improvements	Pumping Optimization and Pressure Improvement	4	High pressure spikes	$50,000

Project	Project Type	Rank	Triggers	Estimate of Probable Project Cost
Lower Malben-Woolston Zone Tank and Connector Piping	Storage, Distribution and Pressure Zone Optimization	1	Growth, pressure zone improvement to reduce system failures	$3,460,000
36-inch main from TTP to control valve	Transmission Rehabilitation	3	System failure, growth and need for capacity improvement	$2,665,000
36-inch main from end of existing 36-inch to Town	Transmission Rehabilitation	2	System failure, growth and need for capacity improvement	$1,726,000
Lower Malben-Woolston Pumping Station (West Side)	Water Quality and Distribution Improvement	5	Water quality and system reliability	$600,000
Benton and Custer Pipe Upsize (Tank Optimization)	Distribution Optimization	6	Water quality and system reliability	$3,200,000
Dalhausen Pump Station Improvements	Pumping Reliability	9	System failure	$150,000
Ten Mile Water Treatment Plant Backwash/Surface Wash Pumping Improvements	Storage Optimization	10	Growth	$240,000
Connect Airport to Low Zone	Distribution Optimization	7	Pressure zone improvement	$450,000
Carter & Highway 12	Distribution Optimization	8	Pressure zone improvement	$100,000
PRV Telemetry	Distribution Optimization	19	Pressure zone improvement	$150,000
Paralleling The 20-inch MRTP Discharge	Distribution Optimization	17	Growth, system reliability	$1,200,000
Paralleling The 24-inch MRTP Discharge	Distribution Optimization	18	Growth, system reliability	$1,080,000
Connect Forest Estates to Reader's Village	Distribution Optimization	12	System reliability and demand	$910,000
Connect Hale Zone to Winne Zone	Distribution Optimization	14	System reliability and demand	$520,000

Project	Project Type	Rank	Triggers	Estimate of Probable Project Cost
Southwest Piping Improvements	Distribution Optimization	13	System reliability and demand	$4,400,000
Hale Zone Piping Improvements	Distribution Optimization	15	System reliability and demand	$3,400,000
Connect West main to Reeder's Village, Upsize Piping, Connect Reeder's to Hale	Distribution Optimization	11	System reliability and demand	$200,000
Connect Winne Zone to Reeder's Village	Distribution Optimization	16	System reliability and demand	$500,000
Fort Harrison booster pumping	Distribution Reliability	20	System reliability and demand	$800,000

The second category of projects includes renewal and replacement and fire flow improvements. These projects are summarized in Table 1-11.

Table 1 -11- Recommended Renewal and Replacement/Fire Flow Improvements Capital Projects

Project	Project Type	Priority Score (0 - 20, 20 = highest)	Service Area	Triggers	Estimate of Probable Project Cost
Front St Improvements	Fire Flow Improvements	15	Central Helena	Pipe Failure, Street Improve ments	$486,530
Chesnut St W	Fire Flow Improvements	14	Central Helena	Pipe Failure, Street Improve ments	$284,610
Jackson Logan Rehab	Fire Flow Improvements	14	Central Helena	Pipe Failure	$389,920

Project	Project Type	Priority Score (0 - 20, 20 = highest)	Service Area	Triggers	Estimate of Probable Project Cost
				Street Improve ments	
Misc Hydrant Laterals	Fire Flow Improvements	14	Central Helena	Pipe Failure Street Improve ments	$2,120
National/Dodge/Phoeni x W	Fire Flow Improvements	14	Central Helena	Pipe Failure Street Improve ments	$408,660
Armor Metals	Fire Flow Improvements	13	East Industrial	Pipe Failure Street Improve ments	$34,320
Misc Hydrant Laterals	Fire Flow Improvements	13	Hale Zone	Pipe Failure Street Improve ments	$1,750
Blake St	Fire Flow Improvements	12	Hale Zone	Pipe Failure Street Improve ments	$83,280
Choteau	Fire Flow Improvements	12	West Side Improvements	Pipe Failure Street	$68,340

Project	Project Type	Priority Score (0 - 20, 20 = highest)	Service Area	Triggers	Estimate of Probable Project Cost
				Improve ments	
Lyndale West	Fire Flow Improvements	12	Central Helena	Pipe Failure Street Improve ments	$567,690
Railroad	Fire Flow Improvements	12	Railroad	Pipe Failure Street Improve ments	$1,400,000
S Davis Improvements	Fire Flow Improvements	12	Hale Zone	Pipe Failure Street Improve ments	$118,520
State St	Fire Flow Improvements	12	Hale Zone	Pipe Failure Street Improve ments	$646,640
3rd St	Fire Flow Improvements	11	Hale Zone	Pipe Failure Street Improve ments	$357,520
Euclid Alley	Fire Flow Improvements	11	West Side Improvements	Pipe Failure Street Improve	$28,270

Project	Project Type	Priority Score (0 - 20, 20 = highest)	Service Area	Triggers	Estimate of Probable Project Cost
				ments	
Gold Ave Phase II	Fire Flow Improvements	11	Central Helena	Pipe Failure Street Improve ments	$296,400
Leslie Ave	Fire Flow Improvements	11	West Side Improvements	Pipe Failure Street Improve ments	$89,150
Park Ave Tie-In	Fire Flow Improvements	11	West Side Improvements	Pipe Failure Street Improve ments	$62,430
Pine	Fire Flow Improvements	11	Hale Zone	Pipe Failure Street Improve ments	$249,670
West Main Improvements	Fire Flow Improvements	11	Hale Zone	Pipe Failure Street Improve ments	$715,090
Allison St	Fire Flow Improvements	10	West Side Improvements	Pipe Failure Street Improve ments	$637,970

Project	Project Type	Priority Score (0 - 20, 20 = highest)	Service Area	Triggers	Estimate of Probable Project Cost
Aspen St E	Fire Flow Improvements	10	Central Helena	Pipe Failure Street Improve ments	$192,190
Beattie	Fire Flow Improvements	10	Hale Zone	Pipe Failure Street Improve ments	$463,210
Chaucer	Fire Flow Improvements	10	Hale Zone	Pipe Failure Street Improve ments	$338,760
Cole Ave E	Fire Flow Improvements	10	Central Helena	Pipe Failure Street Improve ments	$399,650
Columbia Ave	Fire Flow Improvements	10	Central Helena	Pipe Failure Street Improve ments	$475,760
Cutler/Ewing	Fire Flow Improvements	10	Hale Zone	Pipe Failure Street Improve ments	$157,980
Euclid Henderson	Fire Flow Improvements	10	West Side Improvements	Pipe	$181,320

Project	Project Type	Priority Score (0 - 20, 20 = highest)	Service Area	Triggers	Estimate of Probable Project Cost
				Failure Street Improve ments	
Grant St	Fire Flow Improvements	10	West Side Improvements	Pipe Failure Street Improve ments	$1,173,110
Miller	Fire Flow Improvements	10	Hale Zone	Pipe Failure Street Improve ments	$143,370
Montana Ave Phase I	Fire Flow Improvements	10	Central Helena	Pipe Failure	$489,950
Mountain View	Fire Flow Improvements	10	West Side Improvements	Pipe Failure	$700,860
Orange Ave E	Fire Flow Improvements	10	Central Helena	Pipe Failure	$370,850
Poplar St W	Fire Flow Improvements	10	Central Helena	Pipe Failure	$516,050
Spencer/Rodney	Fire Flow Improvements	10	Hale Zone	Pipe Failure	$642,320
Wilder	Fire Flow Improvements	10	West Side Improvements	Pipe Failure	$976,730
Carroll College	Fire Flow Improvements	9	Carroll College	Pipe Failure	$1,200,000
Cruse Ave Crossing	Fire Flow	9	West Side	Pipe	$154,320

Project	Project Type	Priority Score (0 - 20, 20 = highest)	Service Area	Triggers	Estimate of Probable Project Cost
	Improvements		Improvements	Failure	
Garfield	Fire Flow Improvements	9	West Side Improvements	Pipe Failure	$352,890
Hauser	Fire Flow Improvements	9	West Side Improvements	Pipe Failure	$1,187,340
Highland	Fire Flow Improvements	9	Hale Zone	Pipe Failure	$378,290
Hillsdale St	Fire Flow Improvements	9	Hale Zone	Pipe Failure	$848,360
Rhode Island, 1st And 2nd	Fire Flow Improvements	9	Hale Zone	Pipe Failure	$465,210
Walnut St	Fire Flow Improvements	9	East Industrial	Pipe Failure	$1,170,570
Airport Road	Fire Flow Improvements	8	East Industrial	Pipe Failure	$772,990
Centennial Drive	Fire Flow Improvements	8	East Industrial	Pipe Failure	$1,477,310
Elm St E	Fire Flow Improvements	8	Central Helena	Pipe Failure	$301,870
Lamborn/Poplar/Oakes	Fire Flow Improvements	8	Central Helena	Pipe Failure	$450,640
Montana Ave Phase II	Fire Flow Improvements	8	Central Helena	Pipe Failure	$529,050
N Cooke St	Fire Flow Improvements	8	Central Helena	Pipe Failure	$561,130
Orange Ave W	Fire Flow Improvements	8	Central Helena	Pipe	$458,590

Project	Project Type	Priority Score (0 - 20, 20 = highest)	Service Area	Triggers	Estimate of Probable Project Cost
				Failure	
Poplar St E	Fire Flow Improvements	8	Central Helena	Pipe Failure	$436,230
Gold Ave Phase I	Fire Flow Improvements	6	Central Helena	Pipe Failure	$383,860
N Harris St	Fire Flow Improvements	6	Central Helena	Pipe Failure	$573,550
Sanders St	Fire Flow Improvements	6	Central Helena	Pipe Failure	$165,820

The projects summarized in the Tables above are in order of priority considering current conditions. The City should continue to assess priorities on at least an annual basis and adjust as necessary for changing conditions.

Chapter 2: Introduction

Introduction

The City of Helena completed a water facility plan in 2005. The plan evaluated supply and treatment facilities and a hydraulic model was developed for the distribution system. The primary focus of the 2005 Helena Water Facility Plan was on treatment facilities and reversing the roles of the Ten Mile and Missouri River Water Treatment Plants.

The focus of this work effort will be on the transmission, distribution and storage systems including: further development of the water model to include additional piping and demand analysis by meter; evaluations of a lower pressure zone storage tank; pressure zone optimization and elimination of PRV's; water age and distribution system water quality; condition assessment of the Ten Mile transmission main; Woolston tank optimization and; Fort Harrison water system connection. In addition, the recently completed Comprehensive Performance Evaluation for the Ten Mile and Missouri River Treatment Plants will be incorporated. A capital improvement program will be developed identifying priorities and triggers for implementation of recommended projects and providing estimated project costs and an implementation schedule.

This work effort will review, update, where necessary, and build upon information and findings presented in the City's previous planning reports to provide an updated Water Facility Plan for the City of Helena.

This report is organized into seven chapters as follows:

Chapter 1 – Executive Summary

Provides a brief summary of the contents and findings of the plan.

Chapter 2 – Introduction

Provides an overview of the plan and discusses the criteria used as the basis for evaluation of the City of Helena water system.

Chapter 3 – Distribution System Analysis

Describes the water distribution system and analysis of the system utilizing the updated hydraulic model. Summarizes findings with regard to the distribution system contribution of copper and zinc to the wastewater treatment plant.

Chapter 4 – Pressure Zone and Storage Analysis

Provides evaluation of a lower pressure zone storage tank; pressure zone optimization and elimination of PRVs; Reservoir optimization; Fort Harrison connection; energy usage and efficiency; and Lower Malben-Woolston pumping;

Chapter 5 – Treatment Plant Analysis and Comprehensive Performance Evaluation

Provides a summary of the comprehensive performance evaluation of the Ten Mile and Missouri River Water Treatment Plants and bench scale testing for optimization of chemical coagulants for reduction of total organic carbon, copper, and zinc.

Chapter 6 – Recommended Plan

Provides recommendations for improvement to the distribution system and a capital improvement plan for implementation of the recommendations. Basis of Planning Update

Basis of Planning

Population and Planning Areas

Currently, water service is provided in the City limits and to Fort Harrison. Changes since the completion of the 2005 Plan include expansion to the Valley, and east of the Winne Zone (west of Interstate 15). These areas are shown in Figure 2-1.

Population projections used in this Facilities Plan are summarized in Table 2-1, and do not differ from projections included in the 2005 Plan. These projections were based on estimates provided in the Wastewater Treatment Plan (1998) and correspond well with two projections provided in the City of Helena Transportation Plan (2004).

Table 2-1 - Population Projections[1]

	2004	2025	Buildout
City of Helena	31,005	35,986	40,493
Central Valley	330	9,670	15,166
North Valley	0	853	4,588
West Side	540	3,300	4,060
Fort Harrison	162	212	258

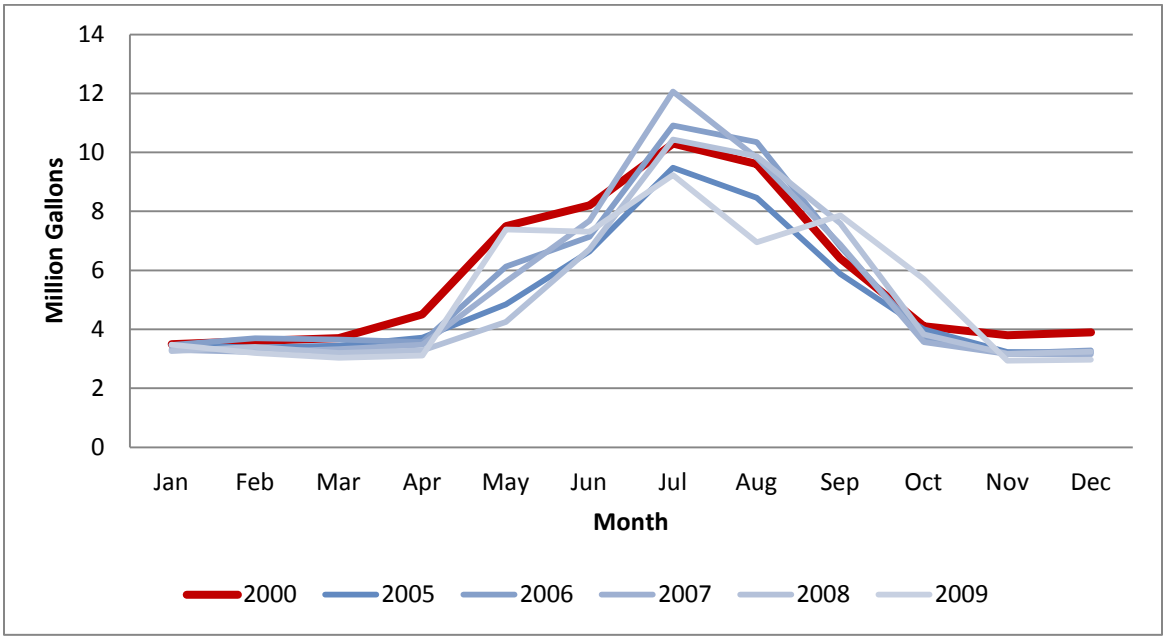
1. Population projections based on 1998 Helena Area Wastewater Treatment Plan

Production and Water Demand

Historic Usage

The average monthly production for 2000 and 2005 through 2009 is shown in Figure 2-2. A seasonal increase in production can be seen during the summer months, primarily due to landscape irrigation and outdoor use. The average annual production reported for each year is the treated water flow delivered to the service area. A summary is included in Table 2-2.

Figure 2-2 - Average Monthly Production



Average annual water use observed in 2009 does not differ significantly from findings of the 2005 Plan. Therefore, per capita demands and maximum to average day ratios from the Plan will be utilized for this Update as well.

Current research indicates that per capita water demands are decreasing. This is largely due to the increased usage of water conserving fixtures within homes, improved irrigation methods and a conservation mindset (AWWA Journal, *Residential Water Use Trends in North America,* Volume 103, Number 2, February 2011). The City observed a much lower per capita demand in 2009 compared to previous years. However, until a more pronounced trend is observed in Helena, the City's water use projections will be based on historical per capita demands.

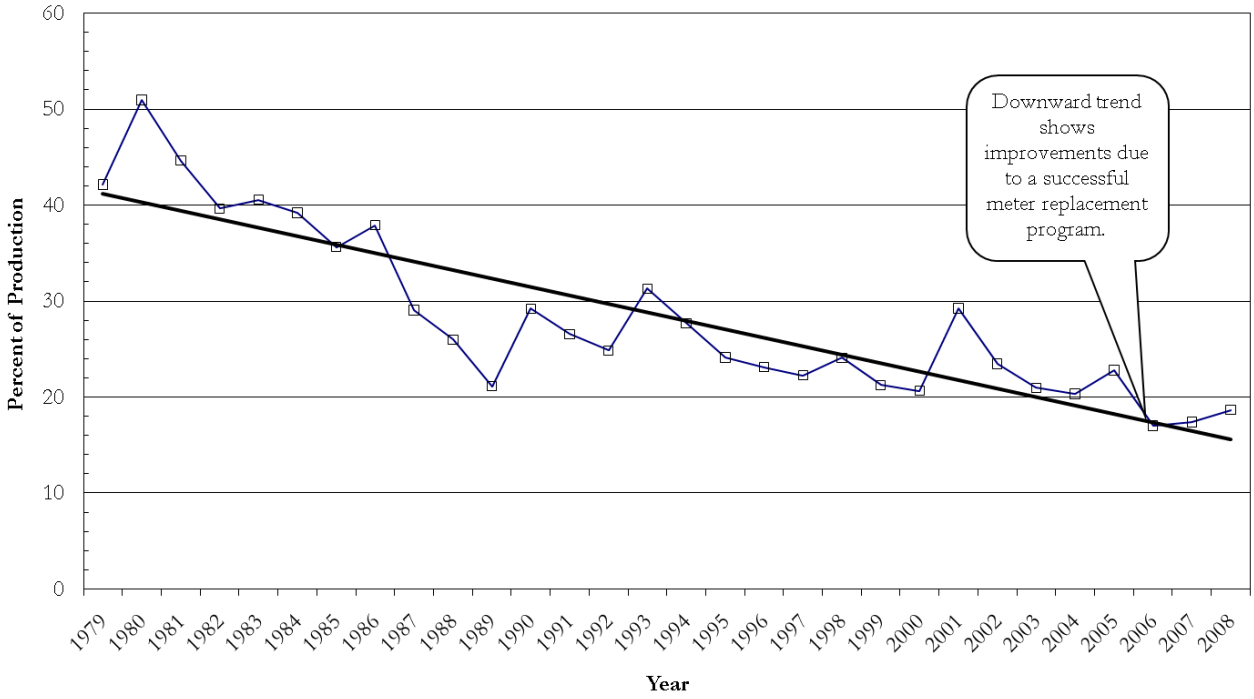
Table 2-2 - Historical Water Production, Population and Per Capita Demand

Year	Population	Average Annual Production (mgd)	Maximum Daily Production (mgd)	Average Per Capita Demand (gpcd)	Maximum Day to Average Day Ratio	Maximum Month Production
1999	29,968	5.1	12.7	171	2.5	August
2000	30,208	5.8	12.3	192	2.1	July
2001	30,578	5.5	11.6	179	2.1	August
2002	30,592	4.9	11.7	157	2.4	July
2003	31,330	5.5	15.7	176	2.9	August
Average		***5.4***	***12.8***	***175***	***2.4***	
2009	35,714	5.3	12.1	147	2.3	July
1. Based on Helena Area Wastewater Treatment Plan Population Projections						

Unaccounted for Water

Unaccounted for water (UAW) use occurs within all water systems and is calculated as the difference between the quantity of water delivered into the distribution system as measured at the treatment plants and the total amount of all water metered to be used by customers. UAW encompasses leaking in the distribution system, conveyance losses, main flushing, fire hydrant flow testing, inaccurate metering and unauthorized connections or use.

Figure 2-3 - Unaccounted for Water 1979 - 2008



UAW trends for the Helena system for the last 31 years can be seen in Figure 2-3. The figure shows that there is a general downward trend in the percentage of water that is unaccounted for, indicating that water loss is gradually being curtailed. Water loss statistics indicated that the system had a loss of about 1.4 billion gallons, or 18 percent in 2008, down from 23 percent in 2002.

In 2006, the City undertook a meter replacement program that replaced over 9,000 meters in the commercial and residential sectors of the City. The City has also added an additional 1,575 meters. The City replaced 10,940 meters and maintains 10,700 customers, which indicates that the replacement program replaced all the meters in the system.

When the replacement program was complete, UAW was anticipated to drop 5 percentage points to approximately 18 percent. Statistics indicate that the meter replacement program was a success.

The City is also tracking other sources of unaccounted for water including flushing water. Flushing water accounted for 4 million gallons of unaccounted for usage in 2009.

Future Demand

Estimating future population and demand is crucial in planning for water system development. Accurately forecasting for water needs will determine the necessary system upgrades that need to be implemented and when they will need to take place in order to meet increasing demand. As there was no significant change to per capita usage and peaking factors described in the 2005 Plan and earlier in this section, future demands projected for 2025 and buildout conditions from the 2005 Plan still apply Table 2-3 and Table 2-4 provide a summary of projected 2025 and buildout demands.

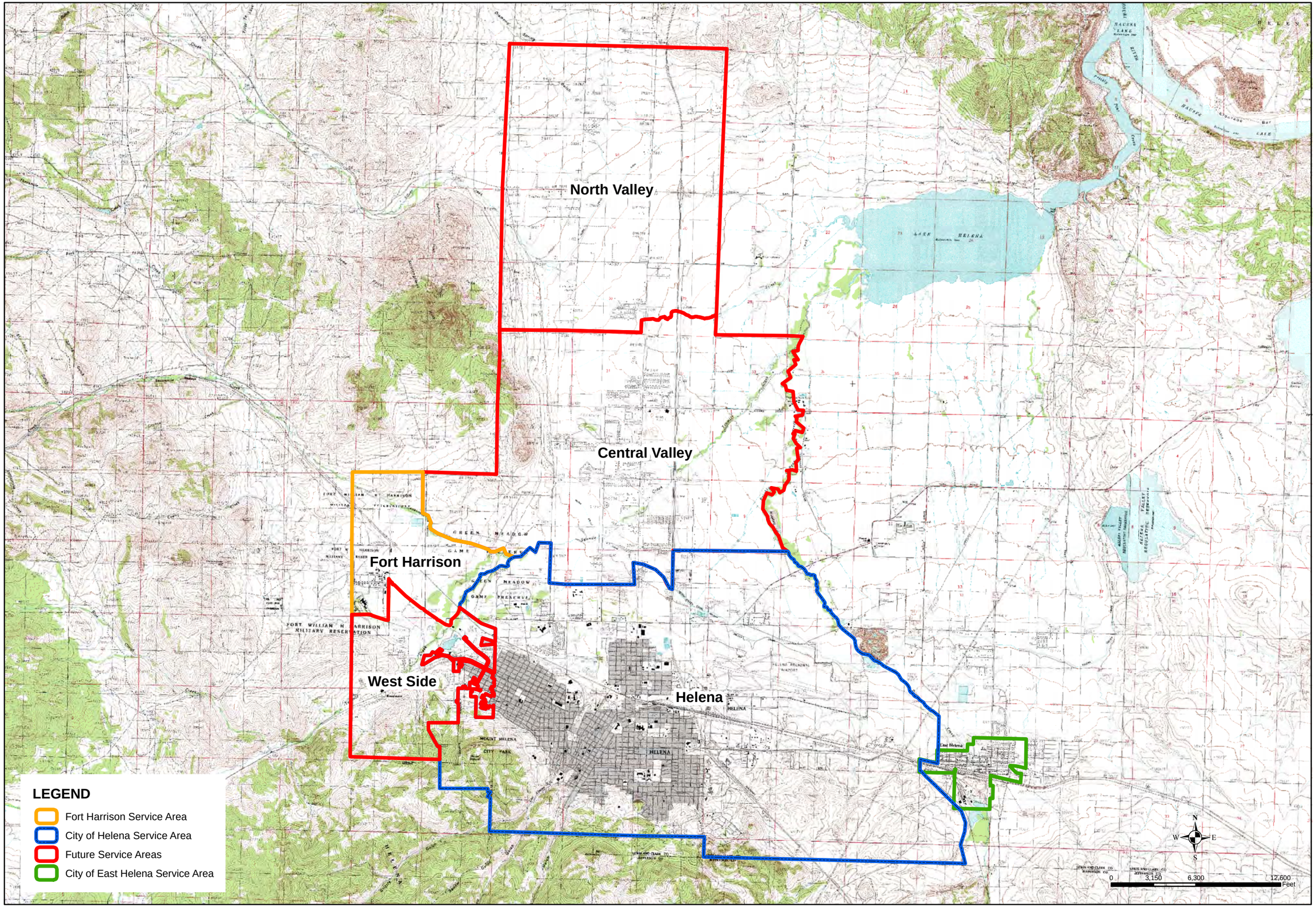
Table 2-3 - 2025 Water Demands for City of Helena Service Area

Planning Area	2025 Population	Average Annual (mgd)	Maximum Day (mgd)	Peak Hour (mgd)
City of Helena (City Limits)	35,986	6.3	15.1	22.0
Central Valley	9,670	1.7	4.1	5.9
North Valley	853	0.1	0.4	0.5
West Side	3,300	0.6	1.4	2.0
Fort Harrison	212	0.0	0.1	0.1
Total	**50,021**	**8.8**	**21.0**	**30.6**

Table 2-4 - Buildout Water Demands for City of Helena Service Area

Planning Area	Buildout Population	Average Annual (mgd)	Maximum Day (mgd)	Peak Hour (mgd)
City of Helena (City Limits)	40,493	7.1	17.0	24.8
Central Valley	15,166	2.7	6.4	9.3
North Valley	4,588	0.8	1.9	2.8
West Side	4,060	0.7	1.7	2.5
Fort Harrison	258	0.0	0.1	0.2
Total	**64,565**	**11.3**	**27.1**	**39.5**

It is estimated that the City of Helena service area will include approximately 50,000 people in 2025. In 2025, the average annual water required will be 8.7 MGD. In 2045, the service area population is estimated to be close to 65,000, and the average daily demand will be 11.3 MGD.



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City of Helena Water Facility Plan Update

Figure 2-1
Helena Planning Areas

April 28, 2011

Chapter 3 – Distribution System Analysis

Introduction

This Chapter describes the water distribution system and analysis of the system utilizing the updated hydraulic water model including pressure, fire flow, and water quality. It also recommends improvements to the system to eliminate deficiencies and provides a detailed evaluation of the Ten Mile Treatment Plant transmission main.

Distribution System Update

Many improvements have been made to the City of Helena's Distribution System since the 2005 Plan including finished water storage and pumping improvements, pressure zone re-configurations, distribution pumping and storage modifications and piping improvements. This Section will discuss these modifications in more detail.

Finished Water Storage and Pumping

Missouri River Water Treatment Plant

In 2008, improvements were made to the Missouri River Treatment Plant. These improvements included:

- 1.5 MG clearwell
- A new pumping station providing 12.6 MGD of pumping capacity for the High Zone Service Area, expandable to 16.8 MGD.
- Replace existing high pressure zone high service pumping with transfer pumps. The transfer pumps will pump from the filter clearwell to the new clearwell
- A new variable frequency drive (VFD) was added to one low pressure zone high service pump.

Additionally, backup power capabilities were added to provide power to one high service pump, one transfer pump and miscellaneous electrical demands.

Pressure Zones

The majority of the system has not been modified since the 2005 Plan with respect to pressure zones with the exception of combining Forrest Estates into a larger pressure zone known as Westside. Westside follows Le Grande Cannon and is roughly bound by University Street to the south, Mount Helena to the north, Mound Street to the east and Silverette Street to the West

Additionally, the City has refined the Upper Malben-Woolston Zone in the vicinity of the Airport to include an Airport pressure zone. There are currently PRVs located off the High Zone discharge line that serve the airport. It is isolated from the rest of the system.

Pressure zones are shown in Figure 3-1.

Pumping and Storage

The following modifications to the City's system were made between 2005 and 2011:

- Missouri River Water Treatment Plant
    - High Zone Pumping
    - Low Zone Pump Station VFD
    - Clearwell
- Westside Storage Tank and Forrest Estates Pump Station Modifications

Distribution System Improvements

The system was described in detail in the 2005 Plan. This section will discuss modifications to the system since the 2005 Plan. Major improvements include:

- Slip lining of 20" Steel in Airport Road
- Laurel Street main Replacements
- Leslie Avenue main replacements

Additionally, several extension projects were put into service including:

- Mountain View Meadows
- Lower Malben-Woolston Zone extensions including areas north and south of Custer Ave
- Reber Phase II Subdivision south of Le Grande Cannon Boulevard

Distribution System Evaluation

Model Update

As part of the Master Plan Update, the model was updated as well. Steps that have been taken since the 2005 plan include the conversion of the model from Bentley WaterCAD to MWHSoft InfoWater. MWHSoft initially converted the model for the City; however, several elements were missing including fire flow requirements, controls and scenarios. HDR, in 2009, added the missing elements, fire flow requirements, controls and scenarios, updated the geometry as improvements had been made to the system, and updated system demands to reflect 2009 demands. Additionally, the revised Missouri River WTP required modification to match the improvements. Our work also included model training and follow-on assistance for City staff.

Additional model updates associated with this Facility Plan effort consisted of:

- GIS Update of Physical System
- Westside Storage Addition and Revision of Forrest Estates Pump Station (and creation of Pressure Zone)
- Demand Allocation by Parcel and City Consumption Records for Maximum and Minimum Demand Conditions with 2010 demands

System Evaluation Criteria

The 75-6-101, et seq., MCA Montana Department of Environmental Quality, Circular DEQ1, Standards for Water Works, indicates that distribution system pressures meet the following criteria:

All water mains, including those not designed to provide fire protection, must be sized after a hydraulic analysis based on flow demands and pressure requirements. The system must be designed to maintain a normal operating pressure of 35 psi. Maximum normal working pressure should be approximately 60 psi. Minimum pressure under all conditions of flow (e.g. fire flows) must be 20 psi.

A detailed evaluation of the Helena water system was completed utilizing the InfoWater™ hydraulic model developed as a part of this facility plan. The evaluation included analysis of pressure under max day demand conditions for current, 2025, and 2045 demands. It also included fire flow analysis under max day demand conditions for the same planning periods and predicted populations. Results from the 2045 analyses are not included due to the degree of expansion required in the system, both from a treatment and pumping standpoint, as well as storage, and the uncertainty as to how those demands would be met.

Existing System Analysis

Pressure Analysis

Maximum Day Pressure Analysis

Initialization

In 2010, the maximum day demand was 12.1 MGD. Population and new service area projections for 2025 indicate an increase of demand to approximately 21.0, and to 27.1 MGD by 2045. Maximum day multiplier is 2.4. Due to the lack of hourly data, no peak hour multipliers were available but a multiplier of 3.5 was estimated.

Existing System Model

A simulation of the maximum day demand conditions was run and pressures below 30 psi are indicated in Table 3-1. The nodes experiencing pressures below 30 psi are confined to the higher pressure zones within the City of Helena specifically in the vicinity of the storage reservoirs and are shown in Figure 3-2.

Table 3-1 - Current Maximum Day Low System Pressures

Description	Number of Nodes below 30 psi	Approximate Maximum Day Pressure, psi	Pressure Zone	Services?
Woolston Reservoir Vicinity	11	19	Upper Malben-Woolston	No
Hale Reservoir Vicinity	13	4	Hale	No
Malben Reservoir Vicinity	1	30	Upper Malben-Woolston	No
Winne Tanks Vicinity	1	11	Winne	No
Nob Hill Reservoir Vicinity	3	9	Upper Malben-Woolston	No

Woolston Nodes

Eleven (11) nodes in the vicinity of the Woolston Reservoirs have static pressures less than 30 psi. Elevations in the area range between 4261 and 4315. The average maximum static pressure in the immediate vicinity is 19 psi. These nodes are located on the reservoir site and pressures below 30 psi do not extend to surrounding homes.

Hale Nodes

Thirteen (13) nodes in the vicinity of the Hale Reservoir and Eureka and Orofino sources, which are located at a relatively high elevation, have static pressures less than 30 psi. These nodes are located on the reservoir site and pressures below 30 psi do not extend to surrounding homes. Elevations in the immediate vicinity range between 4330 and 4360, with average static pressure approximately 4 psi.

Malben Nodes

One (1) node in the immediate vicinity of the Malben Reservoir has a static pressure of approximately 30 psi. Elevation is approximately 4307. No homes are served at this location.

Winne Nodes

One (1) node in the vicinity of Winne Reservoirs No. 1 and 2 has a static pressure of approximately 11 psi. Elevations in the area are about 4477. No homes are served at this location.

Nob Hill Reservoir Nodes

Three (3) nodes in the vicinity of Nob Hill Reservoir have static pressures less than 30 psi. Elevations in the area range between 4294 and 4302. The minimum static pressure is 9 psi, with no homes served in this location.

Fire Flow Analysis

The City of Helena has adopted by reference through ordinance the 1997 Uniform Fire Code (UFC) and is currently reviewing the 2003 UFC for adoption by amendment. The UFC has criteria which establish minimum rates of fire flow for each building within a jurisdiction based upon the building construction type, total floor area, and fire sprinkler availability. In addition, Montana Department of Environmental Quality (MDEQ) requires that under all conditions of flow (e.g., fire flow); minimum pressure must be 20 psi. MDEQ also dictates that the minimum size of water main for providing fire protection and serving fire hydrants must be 6-inch diameter. City of Helena standard is 8-inch and larger, with hydrant laterals sized at 6-inch. Larger size mains will be required if necessary to allow the withdrawal of the required fire flow while maintaining the minimum residual pressure of 20 psi.

For the purposes of this analysis, a minimum zone pressure of 20 psi was used while calculating the available fire flow at each node in the hydraulic model under maximum day demand conditions.

For planning-level analyses, the City of Helena requires a minimum amount of flow to be available depending on the type of land use at a given location. Table 3-2 - indicates fire flow requirements based on land use type.

Table 3-2 - Fire Flow Criteria Based on Land Use Type

Land Use	Required Fire Flow (gpm)
Residential	1,750
Office/Business	1,750
School	1,750
Commercial	1,750
Light Manufacturing	3,750
Industrial	3,750

Existing System Fire Flow Evaluation

As stated, the available fire flow was calculated at each node in the distribution system under maximum day demand conditions while maintaining a minimum zone pressure of 20 psi at the location where the fire flow was being calculated. Figure 3-3 provides an illustration of the resulting fire flow capacity for each node in the distribution system. To determine where fire flow deficiencies existed, the available fire flow for each node was compared to the fire flow required based on the land use classification. Figure 3-4 indicates whether the fire flow availability satisfied fire flow requirements as indicated above for current demands and Figure 3-5 for 2025 demands. Table 3-3 - provides a summary of the nodes where planning level fire flow requirements were not satisfied according to land use.

Table 3-3 - Percent Deficient Nodes According to Fire Flow Requirement

Land Use	Fire Flow Requirement	Total Number of Nodes	Fire Flow Deficiencies	
			No. of Nodes	Percent of Total
Residential/Office /Business/Commercial /School	1,750	3,808	1,295	34 %
Heavy Commercial/Light Manufacturing/Airport	3,750	312	234	75 %
Total		**4,120**	**1,529**	**37 %**

Table 3-4 provides a summary of deficient nodes by pressure zone.

Table 3-4 - Percent Deficient Nodes According to Pressure Zone

Pressure Zone	Total Number of Nodes	Fire Flow Deficiencies	
		No. of Nodes	Percent of Total
Lower Malben Woolston	1,217	253	21 %
Upper Malben Woolston	2,202	737	33 %
Winne	380	85	22 %
Westside	105	16	15 %
Reeders Village	15	0	0 %
Hale	143	66	46 %
Upper Hale	13	4	31 %
Total	**4,075**	**1,161**	**29 %**

As indicated in the table, approximately 29% of the nodes in the system are deficient with the largest percentage of fire flow deficiencies occurring in the heavy commercial/light manufacturing/airport land use categories.

Some of the deficiencies are located in older portions of town which have a large percentage of older pipes with low roughness coefficients (less than 60), small pipe diameters and dead-end lines. The roughness coefficients may be the biggest contributor to the reduction in the available fire flow capacity. A low roughness coefficient results in large friction losses that the system must overcome in order to supply the required fire flows. These occur largely in the southern portion of town and between Custer Avenue and the railroad tracks.

An analysis of the deficiencies within the single-family land use classification indicates that a large number of the fire flow deficiencies occurred on pipes that are not looped. In these cases, the flow must be supplied through a single source and coupled with the low roughness coefficients the dead-end pipes do not provide sufficient fire flow capacity. Fire Flow deficiencies observed on pipes having

diameters that are less than 6-inches are caused by high velocities and friction losses reducing the volume of water that can be supplied in the smaller pipes.

Another area of large fire flow deficiencies is in the downtown area and surrounding commercial areas. Commercial areas require a planning level fire flow of 3,750 gpm, which is excessive for conveyance in a 6-inch or 8-inch pipeline as pipe velocities are over 40 and 20 feet per second respectively. Although it appears that adequate looping is provided, the roughness coefficient for the majority of the pipes in the area are less than 60. While large diameter transmission pipes (i.e., diameter greater than 12-inches) are present in the downtown areas, the fire flow deficiencies that are present are occurring on the smaller diameter pipes. Similar results were observed for the industrial land use classification areas. Some of the industrial land use area deficiencies are close to the 3,750 gpm requirement (on the order of 2,750 to 3,700), but are restricted by 8-inch diameter pipe.

A large number of deficiencies occurred in dead end pipes that are not looped.

Water Quality Analysis

Water quality analysis at Current Average Day demands resulted in fair quality water over the majority of the system, and hot spots located in the upper reaches of the system. Average ages are shown in Table 3-5 .

The areas with the highest water age include the Winne and Upper Hale pressure zones with ages on the order of 290 and 300 hours, respectively. System water quality is on the average of 10 days old.

Table 3-5 – Current Average Water Age by Pressure Zone

Pressure Zone	Average Water Age (hours)
Lower Malben Woolston	190
Upper Malben Woolston	250
Winne	290
Westside	170
Reeders Village	180
Hale	270
Upper Hale	300
SYSTEM AVERAGE	240

Future System Analysis

Pressure Analysis

2025 System Model

A simulation was also run for the maximum day demand conditions for 2025. For the purposes of this analysis, no improvements were noted. Pressures below 30 psi are indicated in Table 3-6 . The nodes

experiencing pressures below 30 psi are confined to the higher pressure zones within the City of Helena specifically in the vicinity of the storage reservoirs. This analysis did not yield a significantly different output than the current maximum day demand, with the exception of 13 additional low pressure nodes, mostly within the vicinity of Le Grande Cannon.

Table 3-6 – 2025 Maximum Day Low System Pressures

Description	Number of Nodes below 30 psi	Approximate Maximum Day Pressure, psi	Pressure Zone	Services?
Woolston Reservoir Vicinity	12	18	Upper Malben-Woolston	No
Hale Reservoir Vicinity	13	4	Hale	No
Malben Reservoir Vicinity	4	29	Upper Malben-Woolston	No
Hale/Winne Zone Interface	5	27	Hale	Yes
Winne Tanks Vicinity	1	11	Winne	No
Nob Hill Reservoir Vicinity	3	9	Upper Malben-Woolston	No

Woolston Reservoir Vicinity

Twelve (12) nodes in the vicinity of the Woolston Reservoirs have static pressures less than 30 psi. Elevations in the area range between 4261.5 and 4315.4. The average maximum static pressure in the immediate vicinity is 18 psi. These nodes are located on the reservoir site and pressures below 30 psi do not extend to surrounding homes.

Hale Nodes

Thirteen (13) nodes in the vicinity of the Hale Reservoir and Eureka and Orofino sources, which are located at a relatively high elevation, have static pressures less than 30 psi. These nodes are located on the reservoir site and pressures below 30 psi do not extend to surrounding homes. Elevations in the immediate vicinity range between 4330 and 4360, with average static pressure approximately 4 psi.

Malben Nodes

Four (4) nodes in the immediate vicinity of the Malben Reservoir have a static pressure of approximately 29 psi. Elevation is approximately 4307. No homes are served at this location.

Hale/Winne Zone Interface

Five (5) nodes in the immediate vicinity of the isolation valve between the Hale and Winne Zones have a static pressure of approximately 27 psi. Elevation is approximately 4301. No homes are served at this location.

Winne Nodes

One (1) node in the vicinity of Winne Reservoirs No. 1 and 2 has a static pressure of approximately 11 psi. Elevations in the area are about 4477. No homes are served at this location.

Nob Hill Reservoir Nodes

Three (3) nodes in the vicinity of Nob Hill Reservoir have static pressures less than 30 psi. Elevations in the area range between 4294 and 4302. The minimum static pressure is 9 psi, with no homes served in this location.

Fire Flow Analysis

As indicated above, the existing system fire flow analysis identified nodes where fire flow availability is less than fire flow requirements. In an attempt to reduce the number of deficiencies, the Year 2025 model was evaluated with settings that were slightly different than that of the existing system. The primary difference between the two analyses was the operation of the Missouri River Water Treatment Low Zone Pump Station and the existence of a Low Zone Reservoir.

The primary difference between the existing and 2025 analysis was the operation of the MRTP Low Zone Pump Station and the existence of a Low Zone Reservoir.

The Year 2025 fire flow analysis did not produce significantly different results when compared to that of the existing system, with the exception of the Lower Malben-Woolston Zone. As shown in Figure 3-5, the resulting fire flow deficiencies for each node in the distribution system is very similar to that of the current fire flow analysis. Existing deficiencies were still present, in worsened conditions, and the extent of the deficient areas expanded.

Water Quality Analysis

Water quality analysis at 2025 Average Day demands resulted in improvements in water age in the system, corresponding largely to an increase in average day demands. Average ages are shown in Table 3-7 .

The areas with the highest water age include the Winne and Upper Hale pressure zones with ages on the order of 270 and 390 hours, respectively. System average decreases from 240 hours (10 days) at current average day demands to 144 hours (6 days) at 2025 average day demands.

Table 3-7 – 2025 Average Water Age by Pressure Zone

Pressure Zone	Average Water Age (hours)
Lower Malben Woolston	70
Upper Malben Woolston	130
Winne	270
Westside	120
Reeders Village	105
Hale	250
Upper Hale	290
SYSTEM AVERAGE	**144**

Recommended System Improvements for Pressure, Fire Flow and Water Quality

The distribution system piping analysis evaluated improvements related to redundancy, reduction in headloss, improvement to fire flow, interconnection of pressure zones and pump stations to improve operability and service, major waterline extensions and rehabilitation projects.

Improvements to Existing System

The following summarizes general recommendations to improve redundancy and operability of the existing system.

1. ***Connection of Winne to Hale.*** The 2005 Water Facilities Plan discussed supplying Hale with a different water source. This is an even larger issue for this plan, as Eureka has been providing less supply in recent years. It also helps with fire flow. $636,000

2. ***Connection of Reeder's Village to West Main and Eureka.*** This connection and upgrades to West Main would provide adequate fire flow in that area. The waterline could also be connected with a PRV to Eureka to supply Hale. $245,000

3. ***Connection of Westside to Reeder's Village.*** This "upper" cross-town connector would provide some benefits in redundancy and better use of storage provisions including taking advantage of the storage reservoir, improving water quality. Current demands on the reservoir are too low to maintain adequate turnover.$1,100,000

4. ***Parallel 20-inch line from MRTP near the airport.*** The 20-inch line is currently a bottle neck for flow coming from MRTP. This will only get worse as flow increases from the MRTP especially if the Low Zone pumps continue to not be used. Headloss at 8 mgd could be reduced by 40 feet.

5. ***Connect Winne Zone to Reeder's Village.*** This connection would result in backup power not being required for the Winne Zone. It also, along with the Reeder's Village-Westside connection would result in one pressure zone for Winne, Westside and Reeder's Village.

This “upper” cross-town connector would provide some benefits in redundancy and better use of storage provisions.

6. ***Parallel or replace 12-inch lines along Custer.*** This improvement becomes necessary if a reservoir is built somewhere in the low zone, presumably in the vicinity of Henderson Ponds or Batch Fields, to provide adequate flow in and out of the reservoir. It also would provide better supply to Green Meadow Drive as the service area extends north. A parallel 16-inch or replacing the 12-inch line with a 20-inch would be required.$2,100,000

7. ***Connection of potential booster pump station from Lower Malben-Woolston Zone to Upper Malben-Woolston Zone.*** This would only be done if a reservoir is built in the Lower-Malben-Woolston Zone. This connection would provide a redundant loop between the Lower and Upper Malben-Woolston Zones.

8. ***Valley Zone Initiation.*** The initiation of the Valley Zone would be accomplished by installation of PRVs near the Helena Valley Canal. This is already in progress.

9. ***Airport Area Interconnection*****.** The airport is currently served by the High Zone with a PRV. This has caused pressure problems at the Airport and along Airport Road when the MRTP pumps turn on. A connection to the Low Zone would mitigate this situation. As part of these improvements a 16-inch interconnect on Washington between the 16-inch lines on Skyway Drive and Airport Road in addition to paralleling the 6-inch interstate crossing to Walnut with a 16-inch main would provide needed system redundancy and looping in the Low Zone.

10. ***Carter and Highway 12.*** The area east of the intersection is also prone to high pressure surges from the pumps turning on at the MRTP. Two PRVs on the two 8-inch lines would help alleviate this situation.

11. ***Monitoring PRVs.*** There are problems with proper operation of PRVs in the system. Adding telemetry at PRVs would allow monitoring of their operation and permit staff to better respond to problems.

Figure 3-6 shows the locations of the existing system improvements and Table 3-8 summarizes the estimated cost of each project.

Table 3-8 - General Improvements Cost Summary

Description	Estimated Cost[1]
Connection of Winne to Hale	$636,000
Connection of Reeder's Village to West Main and Eureka	$245,000
Connection of Westside to Reeder's Village	$1,100,000
Parallel 20-inch line from MRTP near the airport	$1,500,000
Connect Winne Zone to Reeder's Village	$865,000
Parallel or replace 12-inch lines along Custer	$2,100,000
Connection of potential booster pump station from Lower Malben-Woolston Zone to Upper Malben-Woolston Zone	$600,000
Valley Zone Initiation	$29,000,000
Airport Area Interconnection	$550,000
Carter and Highway 12	$122,000
Monitoring PRVs	$184,000
Total	**$ 36,902,000**

[1]Costs adjusted from 2005 Facility Plan to 2011 dollars using ENR 20 City CCI

Fire Flow Improvements

The hydraulic analysis identified many areas within the City that do not meet the minimum required fire flow under Montana DEQ code and the proposed UFC requirements. As a result, the existing system will require many improvements to supply the required fire flow demands.

The recommended improvements generally consist of the installation of the new water mains, upsizing existing water mains, the rehabilitation or replacement of old, pipelines, and the rearranging of pressure zones on the south side.

Recommended improvements to address the areas with fire flow deficiencies were run in the network model with the estimated demands for the Year 2025. Improvements to the system were evaluated in the model by placing the planning-level fire flow demand at the deficient node and running the model to determine if the required minimum residual pressure could be provided at that location.

The recommended improvements generally consist of the installation of new water mains, upsizing existing water mains, the rehabilitation or replacement

of old, impaired pipelines, and the adjustment of pressure zones boundaries on the south side of the system.

Many of the existing pipes within the system experience reduced hydraulic capacity as reflected by the number of fire flow deficiencies that were detected. The roughness coefficient for a pipe is generally an indicator of the physical condition. In this case, the model calibration indicated that approximately 35% of pipes have roughness coefficients below 60, suggesting severe tuberculation or other conditions affecting the capacity of the pipes.

Model calibration indicated severe tuberculation or other conditions affecting pipe capacity.

In some instances, rehabilitating water mains is more expensive than providing a new source to an area. Adjustments to pressure zones are recommended in the vicinity of Le Grande Cannon, University, and at the boundary between the Hale and Upper Hale Zones. Several of these nodes, especially in 2025 and beyond, were unable to maintain residual pressures above 20 psi, and impacted other nodes in the pressure zone, inhibiting fire flow availability in these instances.

Figure 3-7 shows overall fire flow improvements, including parallel water mains, rehabilitation and replacement, increasing diameter and looping. Table 3-9 provides a summary of the recommended improvements. The table includes total pipe length of improvements and estimated project costs.

The main areas of fire flow related improvements include:

1. East Industrial/Manufacturing in the vicinity of the Airport
2. West Side
3. Central Helena
4. Hale Zone
5. Carroll College
6. Area in vicinity of railroad tracks

Table 3-9 - Summary of Recommended Improvements

Description	Length, LF	Estimated Cost[1]
East Industrial/ Airport	15,555	$3,455,190
West Side	28,223	$5,612,730
Central Helena	42,354	$8,741,120
Hale Zone	27,495	$5,609,970
Carroll College	5,525	$1,194,860
Area in Vicinity of Railroad Tracks	7,235	$1,471,840
Total	**126,385 (24 miles)**	**$ 26,085,710**

[1]Costs adjusted from 2005 Facility Plan to 2011 dollars using ENR 20 City CCI

East Industrial/Manufacturing

The area in the vicinity of Airport Road is served through a PRV at Airport Road and "B" Street. The 20-inch steel line originates from the main that extends from the MRTP to the south side of Helena. The other system connection points are two 6-inch lines from the Lower Malben-Woolston areas.

The area is predominantly zoned manufacturing and light industrial, and requires fire flows of 3,750 gallons per minute. The 8-inch line is not sufficient to carry this large of a flow, with really only one route (the 20-inch steel line). The Airport Area Interconnect indicated above will also improve fire flows in this area. Results of this replacement or parallel project would result in all nodes in this area satisfying the 3,750 gpm requirement. These improvements are shown in Figure 3-8. East Industrial can be broken down into several phased projects. Total pipe length to be improved in this area is 15,555 linear feet and is itemized in Table 3-10.

Table 3-10 – East Industrial Improvements

Project Name	Length, LF	Estimated Cost
Airport Road	3,435	$772,990
Armor Metals	172	$34,320
Centennial Drive	6,605	$1,477,310
Walnut St	5,343	$1,170,570
East Industrial Total	**15,555**	**$3,455,190**

West Side

This area is predominantly served by older 4-inch and 6-inch mains. Required fire flows in the area are 1,750 gpm and include low and medium density residential, as well as general commercial zoning. An 8-inch line runs along Hauser that was installed in 1908. 12-inch mains extend along Le Grande Cannon and up Laurel, but there are no consistent connections between the 12-inch main and areas to the

south. Areas of considerable problems are located along the older 8-inch line, at dead ends, and along the 4-inch lines. Additionally, there are several dead end mains, often consisting of 4-inch line. Roughness coefficients are largely below 60, indicating older, tuberculated lines. While it is not feasible to replace all the lines in this area, strategic rehabilitation/replacement and looping would significantly help fire flows in this area. Results of these projects would result in 85-percent of the nodes in this area satisfying fire flow requirements. While the addition of the Westside pressure zone has greatly improved fire flow availability in the upper reaches of this area, Floweree, Stuart, Choteau and Knight still experience fire flow deficiencies. These improvements are shown in Figure 3-9.

West Side improvements are broken up into twelve (12) individual projects ranging in size from 170 linear feet to over 6,000 linear feet with costs ranging from $28,000 to $1.19 million. The larger projects can be phased over time. Total linear footage to be added is over 7,000 linear feet and replaced is 23,000 linear feet and is itemized in Table 3-11.

Table 3-11 – West Side Improvements

Project Name	Length, LF	Project Cost
Allison St	3,365	$637,970
Choteau	342	$68,340
Cruse Ave Crossing	771	$154,320
Euclid Alley	171	$28,270
Euclid Henderson	806	$181,320
Garfield	1,771	$352,890
Grant St	6,363	$1,173,110
Hauser	5,277	$1,187,340
Leslie Ave	446	$89,150
Mountain View	3,674	$700,860
Park Ave Tie-In	312	$62,430
Wilder	4,924	$976,730
West Side Total	**28,223**	**$5,612,730**

Central Helena in CLM/M-I area

This area is bound by I-15 to the east, Custer Avenue to the north, the railroad tracks to the south, and the golf course to the west. During the calibration portion of this project, significant losses due to fire flows were recorded. These indicate highly tuberculated lines. Zoning in this area ranges from single family residential to manufacturing, industrial, and commercial uses. The majority of fire flow issues occur in the manufacturing and industrial areas, however, some failing nodes are located in the residential areas as well. Line sizes range from 2-inch to 12-inch, with the majority of mains in the 4-inch to 8-inch range. While it is not feasible to replace all the lines in this area at a total of over 42,000 linear feet of main at a total cost of $8.7 million in the near term, initial strategic rehabilitation/ replacement and looping would significantly help fire flows in this area. Results of these projects would

result in 90-percent of the nodes in this area satisfying fire flow requirements. These improvements are shown in Figure 3-10 and itemized in Table 3-12.

Table 3-12 – Central Helena Improvements

Project Name	Length, LF	Project Cost
Aspen St E	961	$192,190
Chesnut St W	1,423	$284,610
Cole Ave E	1,938	$399,650
Columbia Ave	2,384	$475,760
Elm St E	1,515	$301,870
Front St Improvements	2,453	$486,530
Gold Ave Phase I	2,150	$383,860
Gold Ave Phase Ii	1,575	$296,400
Jackson Logan Rehab	1,960	$389,920
Lamborn/Poplar/Oakes	2,262	$450,640
Lyndale West	2,855	$567,690
Misc Hydrant Laterals	11	$2,120
Montana Ave Phase I	2,206	$489,950
Montana Ave Phase II	2,405	$529,050
N Cooke St	2,808	$561,130
N Harris St	2,562	$573,550
National/Dodge/Phoenix W	2,049	$408,660
Orange Ave E	1,667	$370,850
Orange Ave W	2,051	$458,590
Poplar St E	1,948	$436,230
Poplar St W	2,391	$516,050
Sanders St	778	$165,820
Central Helena Total	**42,354**	**$8,741,120**

Hale Zone

Due to the higher elevations in this area and older 4-inch and 6-inch lines, several nodes fail to meet fire flow requirements due to the minimum 20 psi pressure constraint. Fire flow requirements in the upper portions of the zone are 1,000 gpm. Recommendations to improve fire flow availability in this area include a 12-inch line south along Beattie from State to the 12-inch line on Rhode Island. Plans for this line are already in place. Other improvements include replacing older 4-inch lines with 6-inch lines and replacing 6-inch main with new 8-inch main. According to City staff, a lot of these lines are brittle and couldn't handle higher pressures. Additionally, extending an upper zone cross town connector would help supplement flows in the zone. These improvements are shown in Figure 3-6 and itemized in Table 3-13.

Table 3-13 – Hale Zone Improvements

Project Name	Length, LF	Project Cost
3rd St	1,787	$357,520
Beattie	2,108	$463,210
Blake St	416	$83,280
Chaucer	1,696	$338,760
Cutler/Ewing	781	$157,980
Highland	1,891	$378,290
Hillsdale St	4,241	$848,360
Miller	717	$143,370
Misc Hydrant Laterals	11	$1,750
Pine	1,160	$249,670
Rhode Island, 1st And 2nd	2,308	$465,210
S Davis Improvements	592	$118,520
Spencer/Rodney	3,090	$642,320
State St	3,120	$646,640
West Main Improvements	3,576	$715,090
Hale Zone Total	**27,495**	**$5,609,970**

Carroll College

Mains in this area consist mainly of 6-inch lines. The college consists of several multi-story buildings and has a fire flow requirement of 3,750 gpm. In order to satisfy this requirement, a 12-inch looped line is recommended, as well as increasing the 6-inch main to 8-inch main. These improvements are shown in Figure 3-7. Improvements include replacing over 5,500 linear feet of main at an estimated total cost of $1.2 million. This project can be phased over time.

Area in Vicinity of Railroad Tracks

The area in the vicinity of the Railroad tracks is predominantly zoned manufacturing and light industrial, and requires fire flows of 3,750 gallons per minute. The majority of water mains in this area are 6-inch and 8-inch cast iron with low roughness coefficients ranging from the high 30s to the low 50s. Many of these lines are not looped. In order to satisfy the 3,750 gpm requirement in these areas, projects would include replacing 6-inch mains with 8-inch and looping lines where practicable. These improvements are shown in Figure 3-8. The Railroad improvements are located on Lyndale and can be phased over time. Total length of pipe is 7,235 linear feet at a cost of $1.4 million.

Future Extensions

The major future extensions will be to the north as the service area grows. Because of the topography, two pressure zones will extend north. The new Valley Zone will include areas east of the interstate and west up to Green Meadow Drive. The Lower Malben-Woolston Zone follows Green Meadow Drive and then across the northern portion of the North Valley. Three main lines are proposed to serve the Valley Zone. A 12-inch along Glass Drive, a 16-inch along Montana Avenue and 12-inch on McHugh Lane

continuing to Dairy Drive. The Lower Malben-Woolston Zone would be served by a 16-inch along Green Meadow and a 12-inch across Valley View Road. This piping backbone would provide sufficient normal pressures as well as adequate fire flow and pressure. The future main waterlines as well as some other interconnects are shown in Figure 3-12.

Tenmile Transmission Main Alternatives Evaluation

Treated water is conveyed from the Tenmile Treatment Plant (TTP) to the City of Helena's storage and distribution system through approximately 6.4 miles of various sized pipes that, for the most part, parallel Highway 12. The conveyance system has limited capacity to deliver treated water to the system. The TTP has a treatment capacity of 8.5 MGD but with the control valve 100% open, only 7.0 to 7.5 MGD can be conveyed through the current transmission main configuration. Multiple pipe failures have occurred on the older sections of pipe and they are at the end of their useful life. In addition, existing control valves are ineffective causing water quality issues, especially when bringing the TTP on line after it has been out of service.

Originating at the TTP, three pipes cover the first two miles of transmission main. These pipes include a 24-inch vinyl lined steel pipe, a 16-inch steel pipe and a 16-inch cast iron pipe. The 16-inch cast iron pipe was installed in 1910, the 16-inch steel in the 1940's and the 24-inch steel in 1980. These pipes combine into a 36-inch cement lined ductile iron pipe that was installed in 1990. There is a control valve on the system at this point. The next 3.2 mile segment of transmission main is a single 36-inch ductile iron pipe that was installed in approximately 1990. This pipe is in good condition and except for issues with air relief saddles has not had a history of failure. The final 1.3 miles of transmission main consists of 24-inch vinyl lined steel pipe and a 14-inch cast iron pipe. The 24-inch steel was installed in approximately 1990 and the 14-inch cast iron was installed in 1910. Similar to the upper section of transmission main, this section has experienced failures and is at the end of its useful life.

Several options were evaluated for renewal and replacement of the old, failing, transmission main. Besides renewal and replacement, options considered increasing transmission main capacity to handle the entire TTP capacity and flow control. Alternative evaluated for the segment of pipe from the TTP to the control valve included the following:

- Slip line 24-inch steel with 20-inch fusible C900
- Pipe burst 16-inch cast iron with 18-inch HDPE or C900
- Construct new 16-inch from control valve to TTP
- Construct new 36-inch from control valve to TTP
- Construct new 24-inch ductile iron pipe form control valve to TTP

Alternatives evaluated for the segment of pipe from the end of the existing 36-inch to the City's distribution system included the following:

- Slip line the 24-inch steel with 20-inch fusible C900
- Pipe burst the 14-inch to 16-inch HDPE or C900

- Construct new 16-inch ductile iron pipe
- Construct new 36-inch ductile iron pipe
- Construct new 24-inch ductile iron pipe

The hydraulic model was used to compare the capacity of each of the alternatives against the capacity of the existing system. The hydraulic model, with the control valve 100% open, predicts a total existing system transmission capacity of 8.57 MGD. This is not realized in the field do to an unknown restriction. The analysis assumes the restriction could be identified and the flow capacity improved. Table 3-14 summarizes the results of the evaluation.

Table 3-14 - Tenmile Transmission Main Alternative Model Results

Individual Segment Alternatives	
Alternative	**Modeled System Capacity**
Existing Piping System	8.57 MGD
Slip Line 24-inch Steel W/20 inch (TTP to Control Valve)	8.48 MGD
Slip Line 24-inch Steel W/20-inch (36-inch to Town)	8.60 MGD
New 36-inch (TTP to Control Valve)	8.78 MGD
New 36-inch (Existing 36-inch to Town)	9.56 MGD
Overall Transmission Main Alternatives	
New 36-inch (TTP to Control Valve and Existing 36-inch to Town)	10.26 MGD
Slip Line 24-inch and Replace 16-inch W/18-inch and 14-inch W/16-inch	9.1 MGD

The overall transmission main alternatives include:

- Replacing the older pipe segments from the TTP to the control valve and from the end of the existing 36-inch to town with new 36-inch ductile iron pipe
- Slip lining the existing 24-inch with 20-inch and replacing the existing 16-inch with 18-inch and the existing 14-inch with 16-inch

Replacing the older pipe segments with new 36-inch ductile iron pipe results in the overall highest transmission capacity, however; both overall alternatives result in a transmission capacity capable of conveying the total TTP treatment capacity.

Estimates of probable construction cost were developed for the individual pipe segment options. Table 3-15 summarizes these costs.

Table 3-15 - Individual Pipe Segment Cost Summary

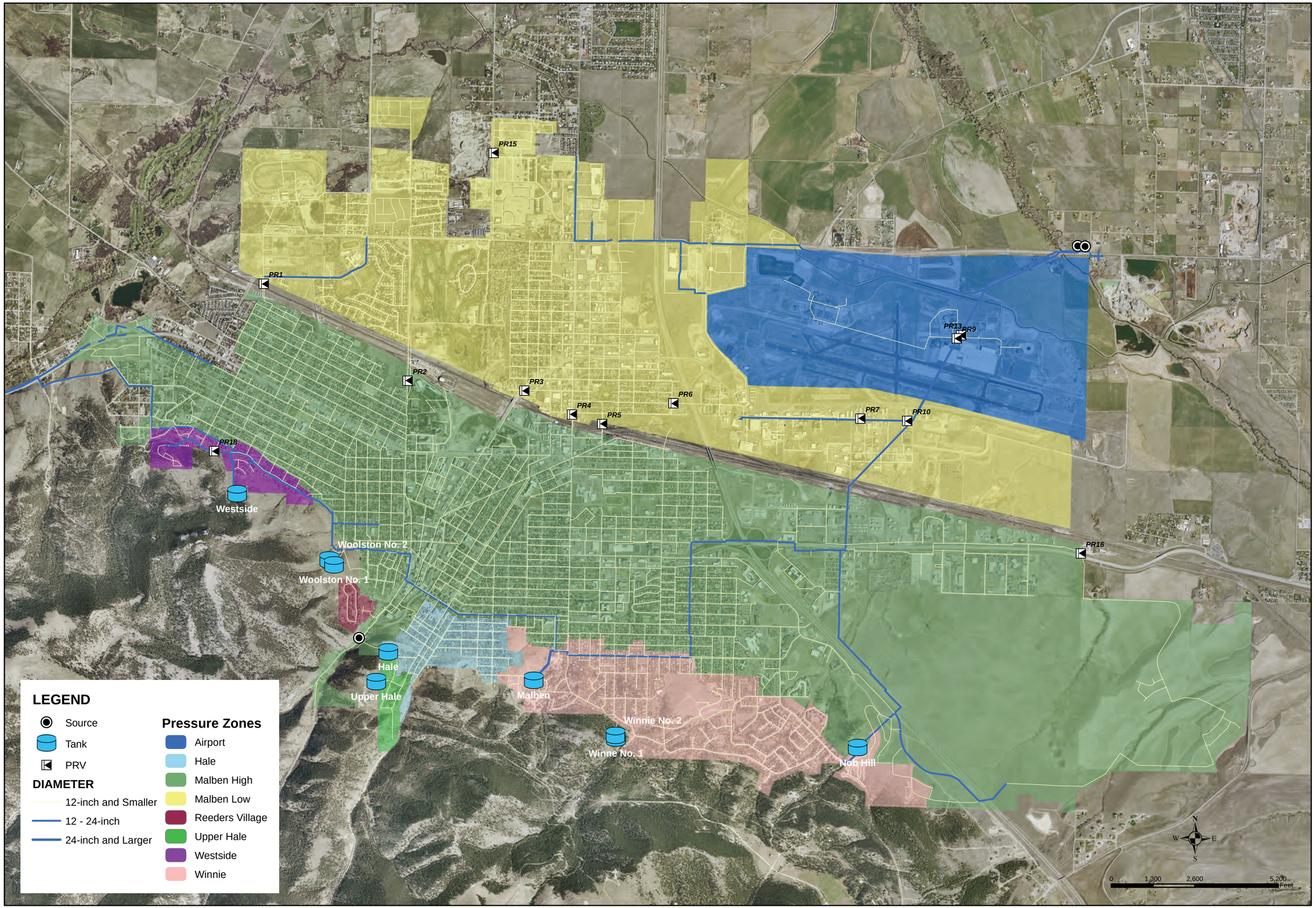
TTP to Control Valve	
Alternative	**Estimated Cost**
Slip Line 24-inch Steel W/20-inch	$1,593,000
Pipe Burst 16-inch Cast Iron W/18-inch	$2,975,400
New 18-inch Ductile Iron	$1,300,000
New 36-inch Ductile Iron	$2,665,000
New 24-inch Ductile Iron	$1,793,680
Existing 36-inch to Town	
Alternative	**Estimated Cost**
Slip Line 24-inch Steel W/20-inch	$1,035,750
Pipe Burst 14-inch W/16-inch	$1,944,450
New 16-inch	$760,000
New 36-inch	$1,726,250
New 24-inch	$1,161,440

There is an array of alternatives available for renewal and replacement, capacity improvement and control improvement of the Ten Mile transmission main. Table 3-16 summarizes the estimated cost of the overall alternatives evaluated.

Table 3-16 - Tenmile Transmission main Alternative Cost Comparison

	Tenmile Transmission Main Alternative Cost Comparison		
Alternative	**Pipe Length (Miles)**	**Pipe Routing**	**Estimated Cost**
Slip Line 24-inch Steel W/20-inch	2.0	TTP to Control Valve	$1,593,000
Slip Line 24-inch Steel W/20-inch	1.3	End of Existing 36-inch to Town	$1,035,750
Pipe Burst 16-inch Cast Iron W/18-inch	2.0	TTP to Control Valve	$2,975,400
Pipe Burst 14-inch Cast Iron W/16-inch	1.3	End of Existing 36-inch to Town	$1,944,450
Total Option Cost	**6.6**		**$7,548,600**
Alternative			**Estimated Cost**
New 36-inch	2.0	TTP to Control Valve	$2,665,000
New 36-inch	1.3	End of Existing 36-inch to Town	$1,726,000
Total Option Cost	**3.3**		**$4,391,000**
Alternative			**Estimated Cost**
Slip Line 24-inch Steel W/20-inch	2.0	TTP to Control Valve	$1,593,000
Slip Line 24-inch Steel W/20-inch	1.3	End of Existing 36-inch to Town	$1,035,750
New 18-inch Ductile Iron	2.0	TTP to Control Valve	$1,300,000
New 16-inch Ductile Iron	1.3	End of Existing 36-inch to Town	$760,000
Total Option Cost	**6.6**		**$4,688,750**
Alternative			**Estimated Cost**
New 24-inch	3.3	TTP to Control Valve and End of 36-inch to Town	$2,955,120
New 18-inch Ductile Iron	2.0	TTP to Control Valve	$1,300,000
New 16-inch Ductile Iron	1.3	End of Existing 36-inch to Town	$760,000
Total Option Cost	**6.6**		**$5,015,120**

The least cost overall alternative is replacing the existing older segments of pipe from the TTP to the control valve and from the end of the existing 36-inch ductile iron pipe to town with new 36-inch ductile iron pipe. This alternative also results in the highest system capacity. This alternative doesn't provide long term redundancy but in the short term, the existing piping could be left in place and used if maintenance is required on the new 36-inch pipe. The importance of redundancy will be reduced as storage and pumping in the Lower Malben-Woolston zone is improved and the Missouri River Water Treatment Plant is used more.



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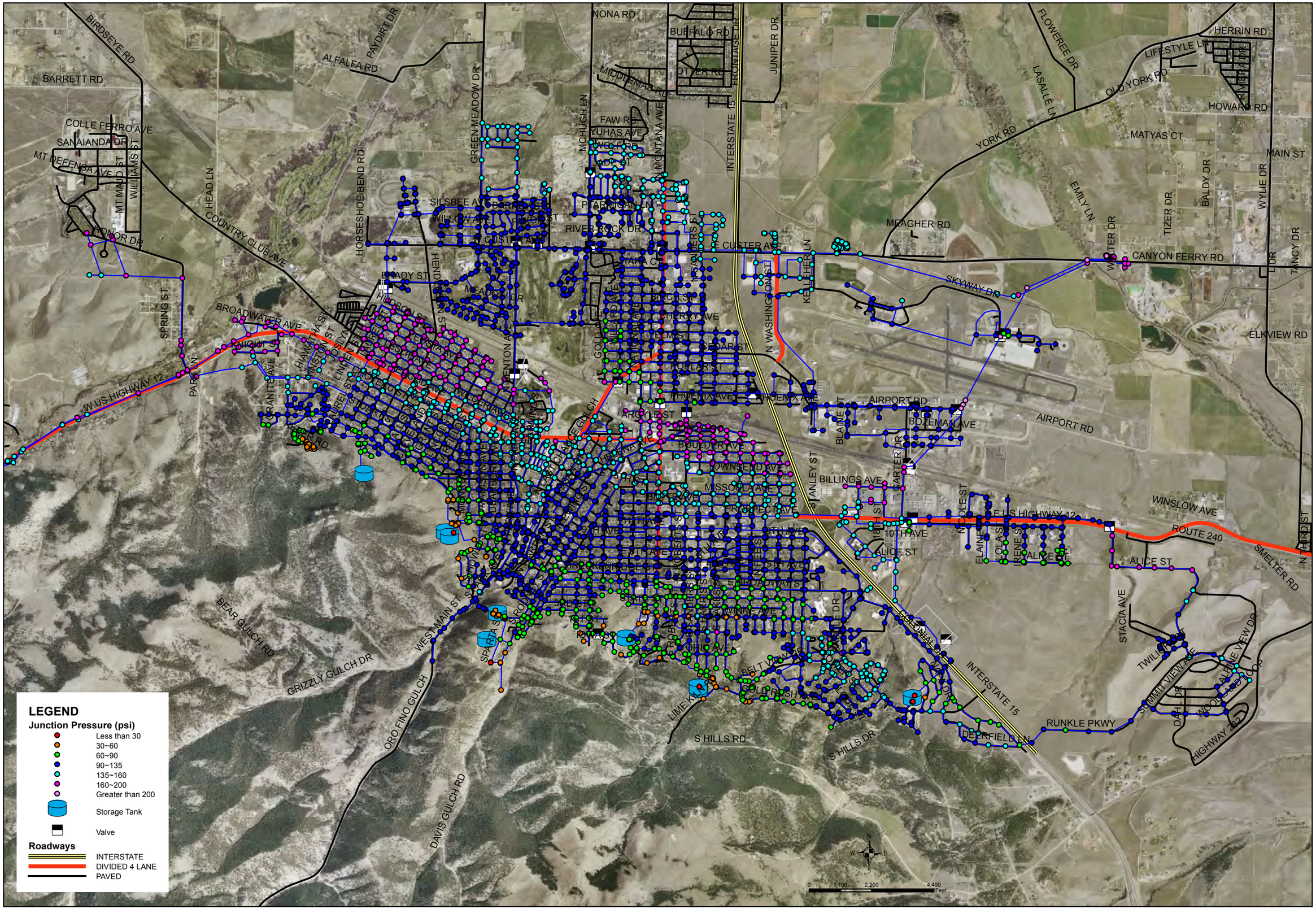
City of Helena Water Facility Plan Update

Figure 3-1
Water System Pressure Zones

April 28, 2011



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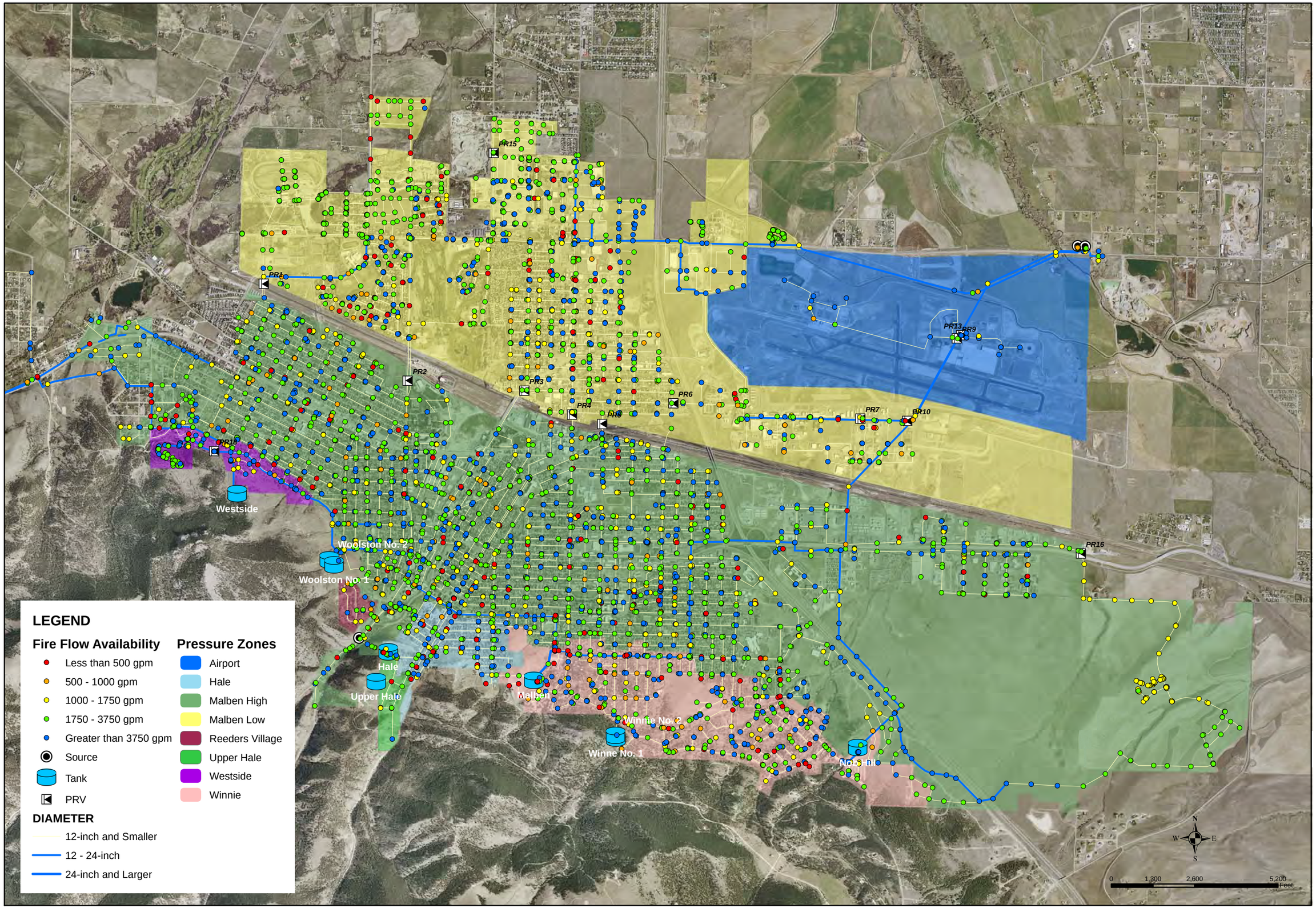
HDR

City of Helena Water Facility Plan Update

Figure 3-2
Maximum Day Pressures

January 6, 2012



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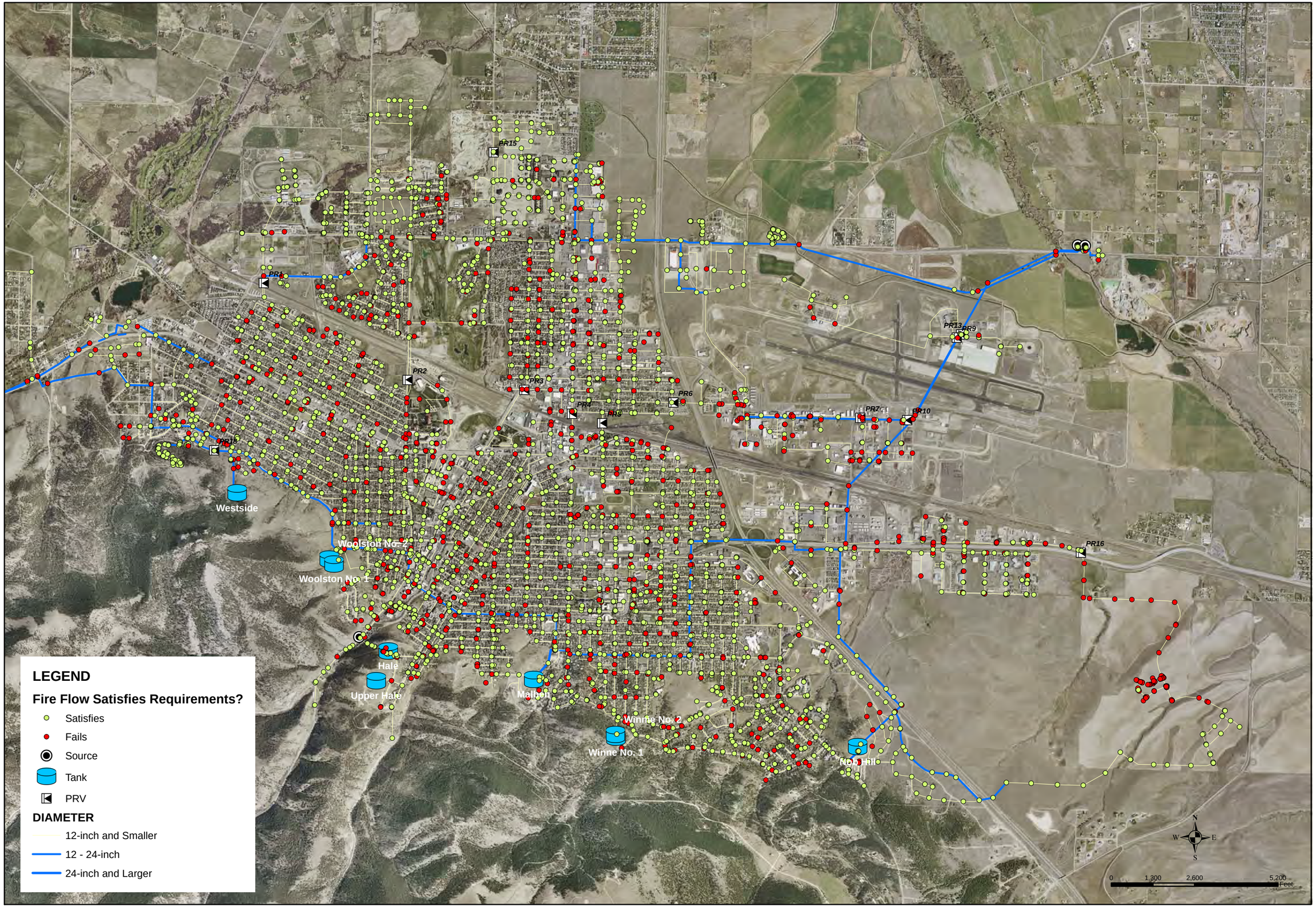
City of Helena Water Facility Plan Update

Figure 3-3
Existing Fire Flow Availability

August 10, 2011



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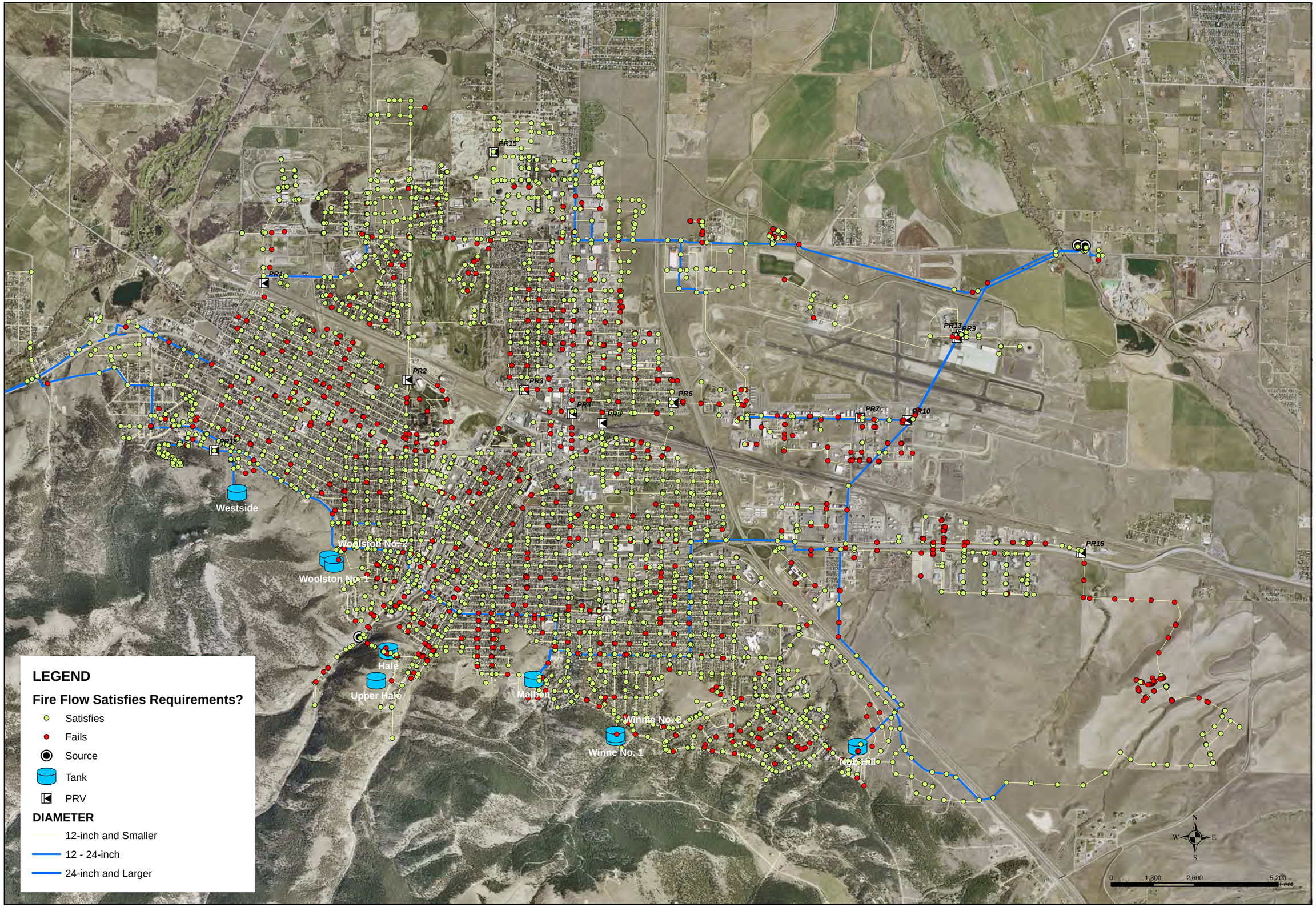
City of Helena Water Facility Plan Update

Figure 3-4
Existing Fire Flow Analysis Deficiencies

August 10, 2011



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City of Helena Water Facility Plan Update

Figure 3-5
2025 Fire Flow
Analysis Deficiencies

August 10, 2011

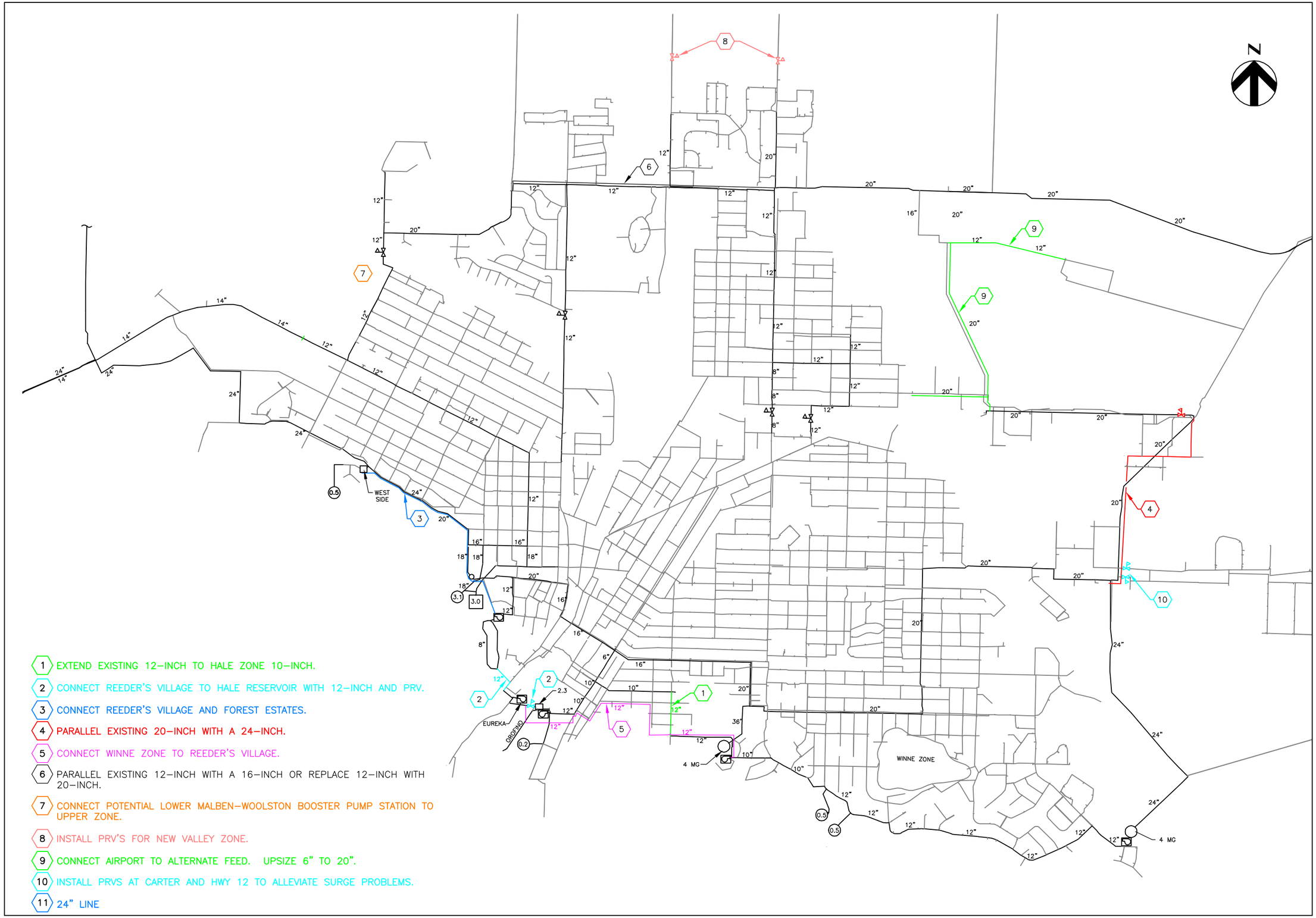

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Figure 3-6
Existing Distribution System Piping Upgrades

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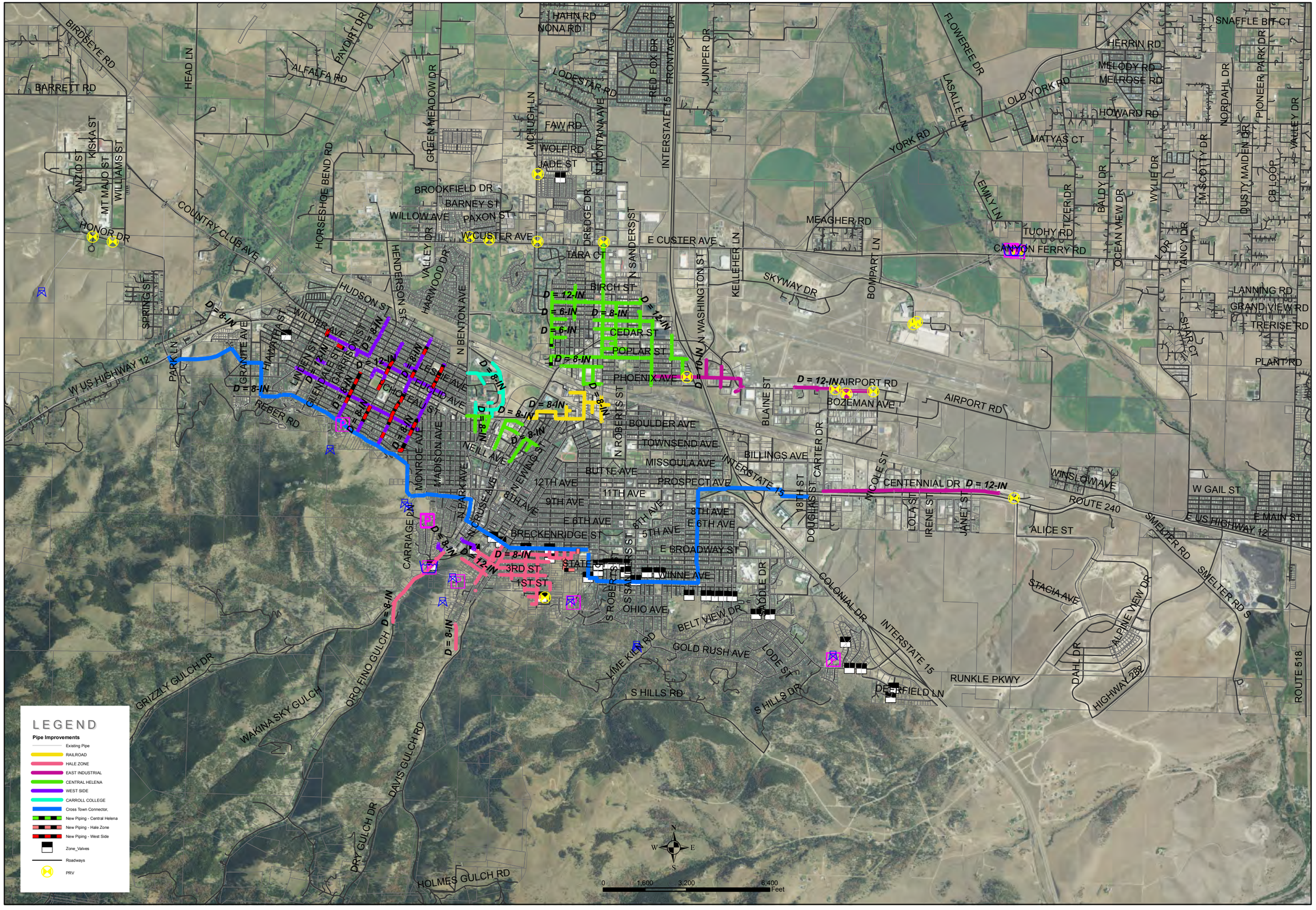

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Figure 3-7
Fire Flow Related Improvements

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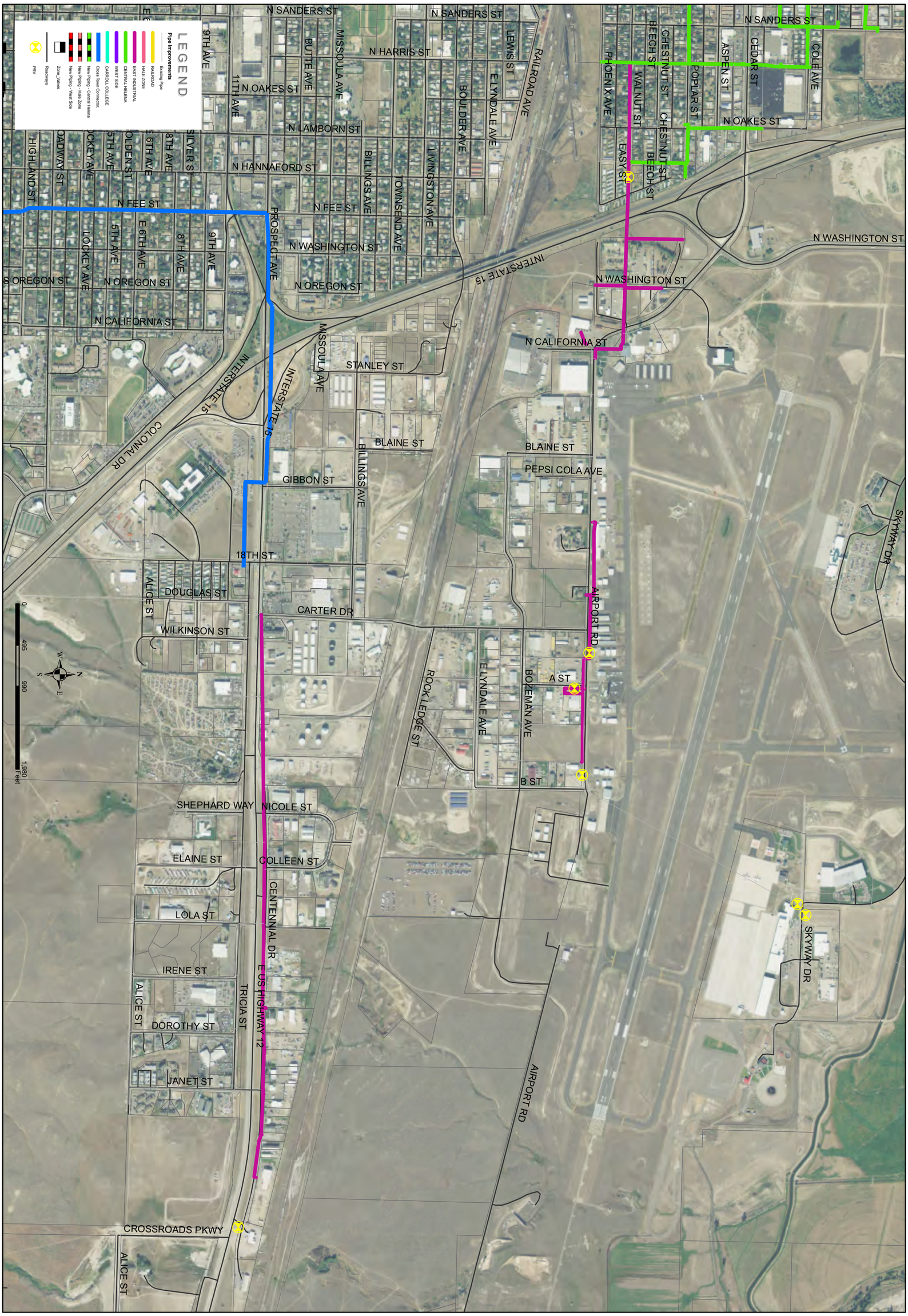

Figure 3-8
East Industrial
Fire Flow Improvements

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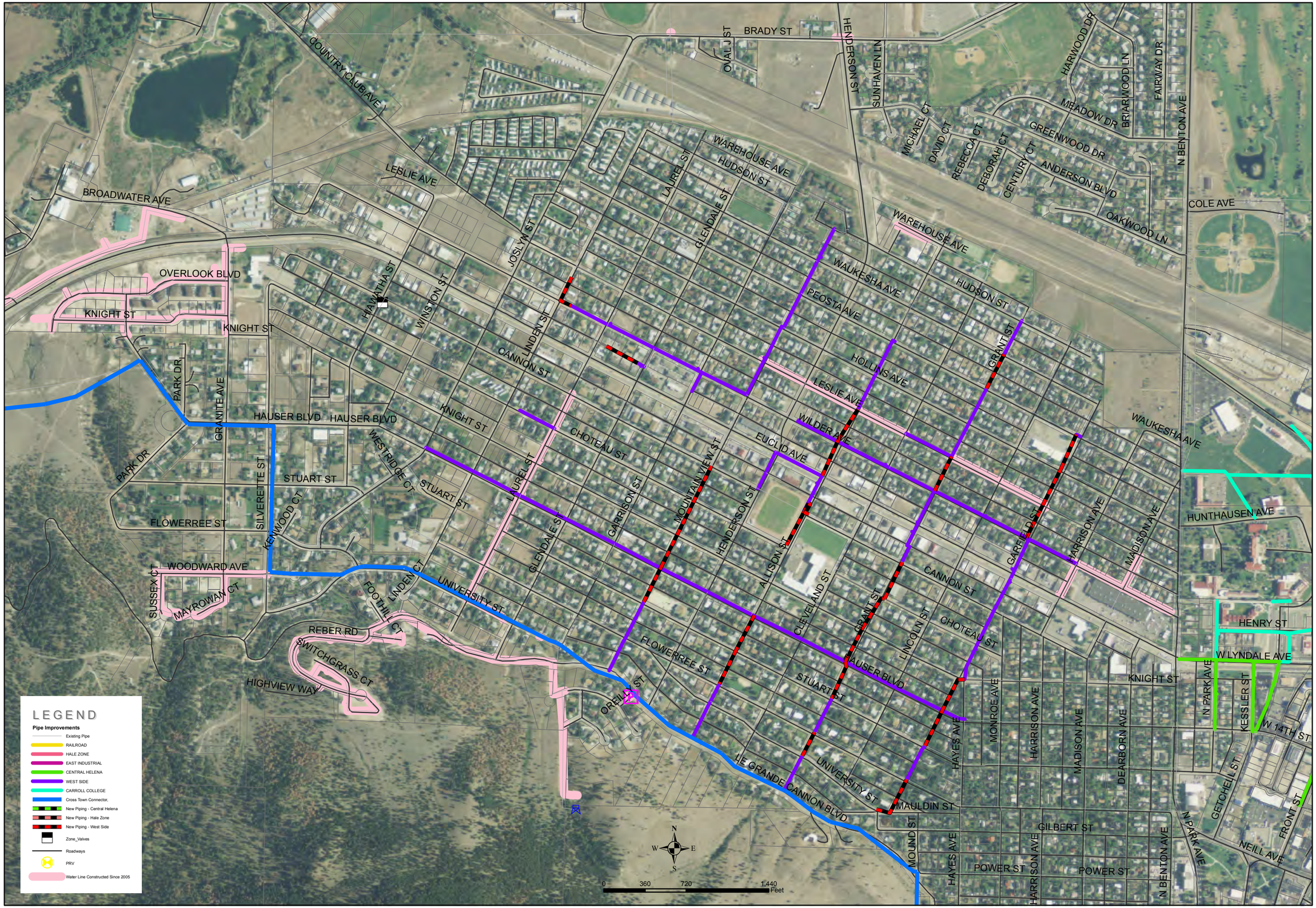

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Figure 3-9
West Side
Fire Flow Improvements

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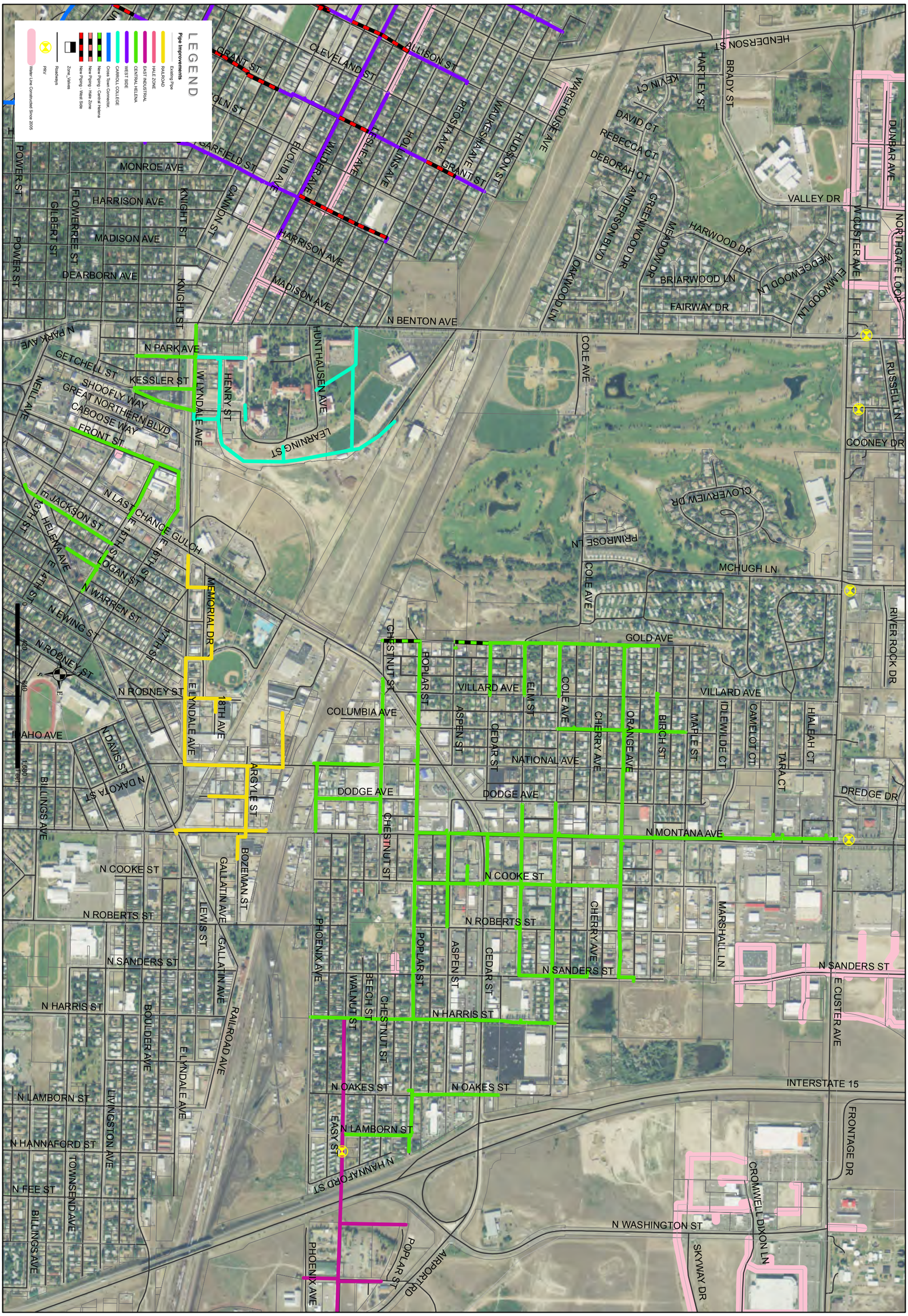

Figure 3-10
Central Helena,
Carroll College and Railroad
Fire Flow Improvements

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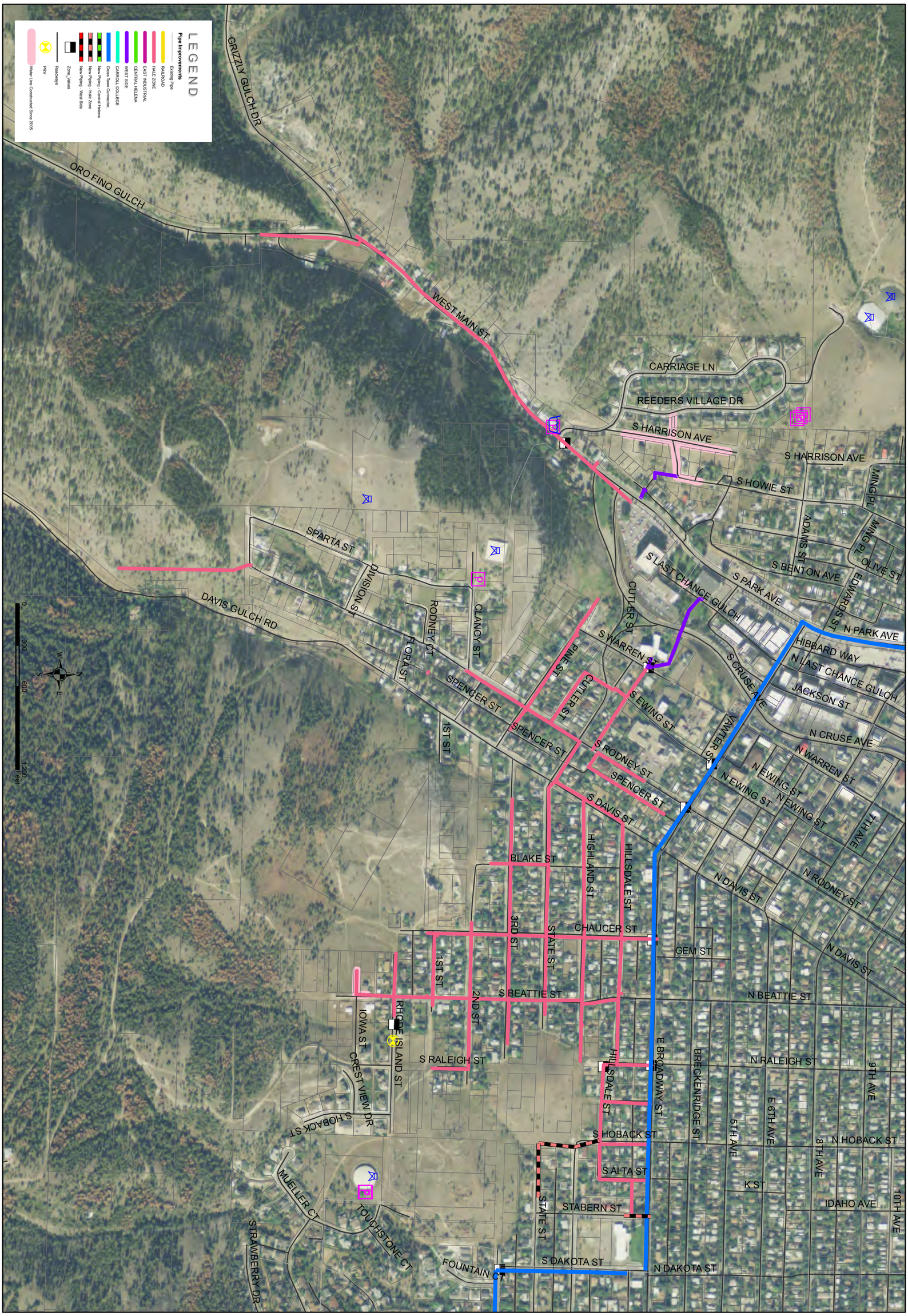

Figure 3-11
Hale Zone
Fire Flow Improvements

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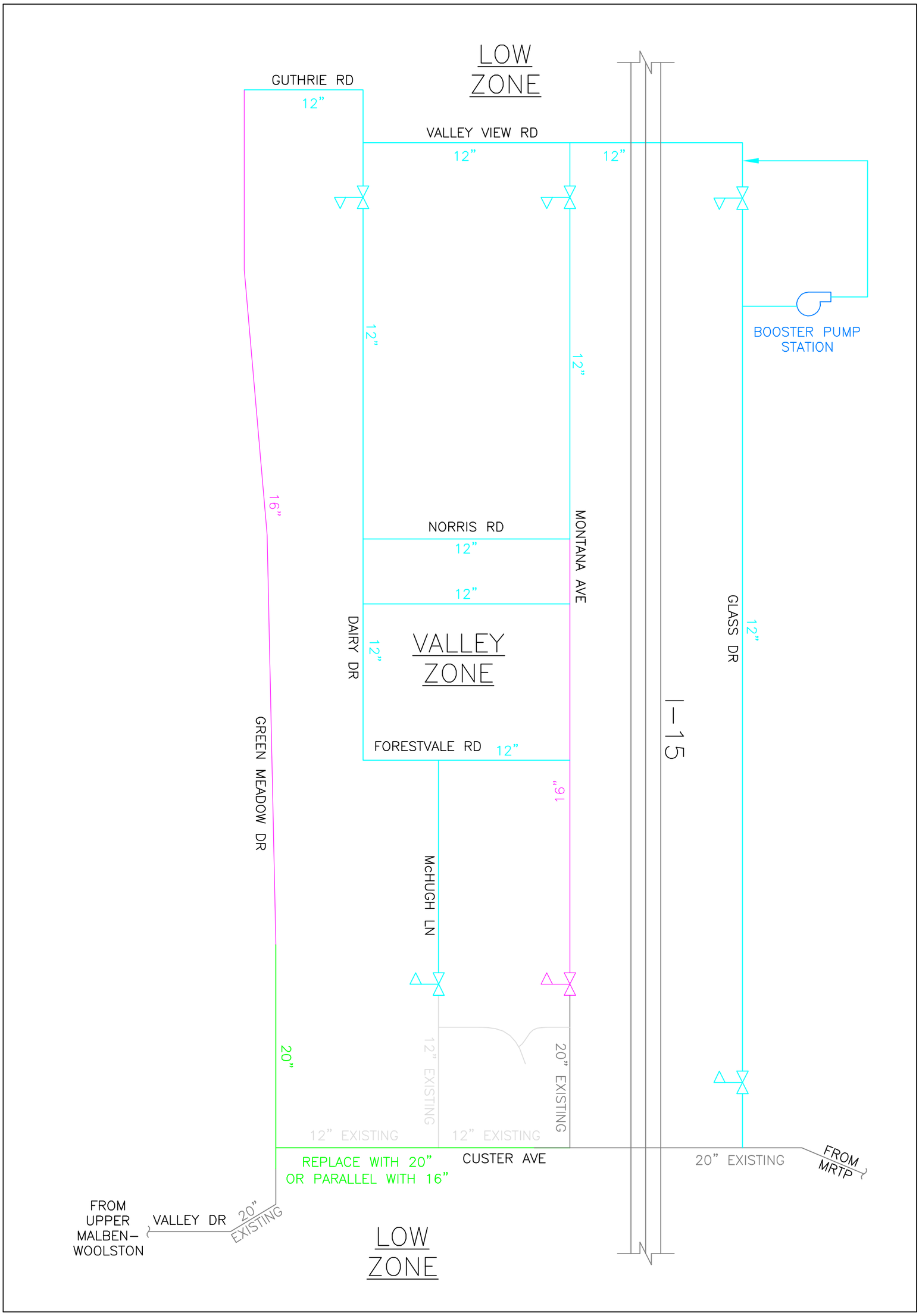

Figure 3-12
Valley Zone/Lower Malben-Woolston Future Pumping Schematic

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Chapter 4: Pressure Zone and Storage Analysis

Introduction

The City's distribution system consists of two large pressure zones, the Upper and Lower Malben-Woolston Zones, and five smaller zones, the Winne, Hale, Upper Hale, Reeder's Village and Westside Zones. The Westside zone was added since the 2005 facility plan was completed. It combined the Forest Estates zone with the upper portion of the Upper Malben-Woolston Pressure zone that had previously exhibited low pressure and fire flow capacity. The Hale zone boundary was modified since the 2005 Facility Plan, incorporating a portion of it into the Winne Zone.

There are nine water storage reservoirs and two clearwells within the City of Helena water distribution system: Nob Hill, Woolston No. 1, Woolston No. 2, Malben, Winne No. 1, Winne No. 2, Hale, Upper Hale, Westside, Ten Mile Treatment Plant Clearwell, and Missouri River Treatment Plant Clearwell. See Table 4-1 below for a summary of reservoirs, their capacity and the pressure zones they serve.

Table 4-1 – Existing Storage Volume Summary

Pressure Zone	Reservoir	Total Volume (MG)	Available Volume[1] (MG)	Zone Totals (MG)
Upper Hale	Upper Hale	0.20	0.20	0.20
Winne	Winne No. 1	0.50	0.50	1.0
	Winne No. 2	0.50	0.50	
Hale	Hale	2.20	2.20	2.20
Westside	Westside	0.50	0.50	0.50
Upper Malben-Woolston	TMTP Clearwell	3.92	2.84	9.54
	Woolston No. 1	3.00	0.00	
	Woolston No. 2	3.10	0.00	
	Malben	4.00	2.70	
	Nob Hill	4.00	4.00	
Lower Malben-Woolston	MRTP Clearwell	1.50	0.75	0.75

[1]Reservoir Volume that is usable during normal water demand.

There are eight pumping stations located within the City of Helena water distribution system. Three of these pumping stations are located at the MRTP. One transfers treated water from the old MRTP Clearwell to the new clearwell and the other two pump water into the Lower and upper Malben-Woolston Zones. The remaining pumping stations function to transfer stored water from a lower zone into a higher-pressure zone within the system. Table 4-2 provides a summary of distribution system pumping stations.

Table 4-2 - Distribution Pumping Station Summary

Description	No. of Pumps	Capacity (GPM)	Size (HP)	Firm Capacity[1] (GPM)	Backup Power
Lower Malben-Wooston Zone	3	1040, 2080, 2080	125, 300, 300	3000	No
Upper Malben-Woolston Zone	3	3010	600	6020	Yes[1]
Dalhausen	3	700, 700, 1100	60, 60, 75	1400	No
Eureka	2	400	60	400	No
Upper Hale	2	80	10	80	No
Nob Hill	2	900	50	900	No
Reeder's Village	3	75, 150, 1750	5, 10, 75	225	Yes
Forest/Westside	3	30, 500, 500	3, 25, 25	530	No

[1]Backup power sized to run one high service pump, and one transfer pump to allow 4 MGD to be pumped to Upper Malben-Woolston Zone.

The 2005 Water Facility Plan provided a detailed description and analysis of the pressure zones and reservoirs within the City of Helena's water system. System changes resulting from the 2005 Water Facility Plan included: Construction of the new MRTP Clearwell and High Service Pumping Station; construction of the Westside Tank; combining the Forest Estates pressure zone with the upper portion of the Upper Malben-Woolston pressure zone; and modification of the Hale zone boundary. Other storage and pressure zone issues identified in the 2005 Water Facility Plan included: The inability to fully utilize the volume of the Woolston No. 1 and No. 2 reservoirs; inability to fully utilize the volume of the Malben Reservoir; and Hale Reservoir discharge control. In addition, several other issues have been identified and are in need of further evaluation. They include water quality in the Westside Reservoir, potential for cross connection from the Fort Harrison water system to the City of Helena water system, and Lower Malben-Woolston zone pumping efficiency and operational challenges.

This Chapter expands on the system evaluation completed in the 2005 Water Facility Plan and includes a detailed evaluation of alternatives for: Constructing a lower Malben-Woolston Zone storage tank; optimizing existing pressure zones; elimination of PRV's; Woolston tank optimization; improving the Fort Harrison water system connection to the City system; Hale tank optimization; West Side tank optimization; Lower Malben-Woolston Zone pumping, and evaluation of energy usage and efficiency improvements.

Lower Malben-Woolston Tank

A detailed storage analysis was completed as part of the 2005 Water Facility Plan. Provisions for a fire event, emergency storage, and equalizing storage were considered under current (2005) and 2025 conditions. The following assumptions and rules were used in analyzing the system storage and identification of storage improvements:

- Evaluate storage based on an individual pressure zone.
- Use of storage in zone of lower hydraulic grade for a higher zone requires the following:
    - If inadequate storage for fire, a properly rated and tested fire pump is required.
    - Firm pump capacity is supplied to meet peak hour demands.

    - Backup power is required for fire pump and peak hour demand pump.
- A single fire event at any given location at a time.

As stated above, improvements to the water system have been constructed since the evaluation was completed in 2005. Based on the assumptions and rules presented above, Table 4-3 provides updated current storage requirements taking into consideration the system improvements.

Table 4-3 - Current Storage Requirements

Zone	Equalizing Storage (MG)	Fire Flow (MG)	Emergency (MG)	Total Required (MG)	Available (MG)	Shortage/Surplus (MG)
Upper Hale	0.00	0.21	0.01	0.22	0.20	-0.02
Winne	0.17	0.21	0.56	0.94	1.00	0.06
Hale	0.04	0.21	0.14	0.39	2.20	1.81
Westside	0.02	0.21	0.06	0.28	0.50	0.22
Reeder's Village	0.01	0.21	0.04	0.26	0.00	-0.26
Upper Malben-Woolston	1.15	0.68	3.84	5.67	9.54	3.87
Lower Malben-Woolston	0.42	0.68	1.40	2.50	0.75	-1.75
Valley	0.00	0.00	0.00	0.00	0.00	0.00
Total	**1.82**	**2.40**	**6.05**	**10.27**	**14.19**	**3.92**
Total w/o Hale	**1.77**	**1.98**	**5.90**	**9.65**	**11.79**	**2.14**
Total Malben-Woolston	**1.57**	**1.35**	**5.25**	**8.17**	**10.29**	**2.12**

Table 4-4 provides a current storage analysis summary.

Table 4-4 - Current Storage Analysis Summary

Zone	Analysis
Upper Hale	Requires additional 0.02 MG (due to new fire flow requirements for zone)
Winne	Adequate
Hale	Adequate
Westside	Adequate
Reeder's Village	No modifications needed as pump station has fire pump, redundant peak hour pumps and backup power
Upper Malben-Woolston	Adequate
Lower Malben-Woolston	Adequate if based on storage in Upper Malben-Woolston Zone
Valley	Valley Zone is not connected to the system under current conditions

Table 4-5 provides updated 2025 storage requirements taking into consideration the system improvements.

Table 4-5 - 2025 Storage Requirements

Zone	Equalizing Storage (MG)	Fire Flow (MG)	Emergency (MG)	Total Required (MG)	Available (MG)	Shortage/Surplus (MG)
Upper Hale	0.00	0.21	0.02	0.23	0.20	-0.03
Winne	0.21	0.21	0.70	1.12	1.00	-0.12
Hale	0.05	0.21	0.17	0.43	2.20	1.77
Westside	0.02	0.21	0.07	0.30	0.50	0.20
Reeder's Village	0.02	0.21	0.05	0.28	0.00	-0.28
Upper Malben-Woolston	1.65	0.68	5.49	7.81	9.54	1.73
Lower Malben-Woolston	0.77	0.68	2.57	4.02	0.75	-3.27
Valley	0.42	0.68	1.39	2.49	0.00	-2.49
Total	**3.14**	**3.08**	**10.45**	**16.68**	**14.19**	**-2.49**
Total w/o Hale	**3.08**	**2.66**	**10.27**	**16.02**	**11.79**	**-4.23**
Total Malben-Woolston	**2.42**	**1.35**	**8.06**	**11.83**	**10.29**	**-1.54**

Table 4-6 provides an updated 2025 storage analysis summary.

Table 4-6 - 2025 Storage Analysis Summary

Zone	Analysis
Upper Hale	Requires additional 0.03 MG (due to new fire flow requirements for zone)
Winne	Requires additional 0.12 MG
Hale	Adequate
Westside	Adequate
Reeder's Village	No modifications needed as pump station has fire pump, redundant peak hour pumps and backup power
Upper Malben-Woolston	Adequate
Lower Malben-Woolston	Requires an additional 1.54 MG if based on storage in Upper Malben-Woolston Zone
Valley	Requires 2.49 MG of storage under predicted 2025 conditions

The Lower Malben-Woolston and Valley Zones need 4.03 MG of storage to meet projected 2025 demands if the excess capacity of the Upper Malben-Woolston Zone is taken into consideration. The storage requirements of these zones can be met by either improving storage capacity in the Upper Malben-Woolston Zone or by constructing new storage in the Lower Malben-Woolston and Valley Zones or a combination of both. The 2005 Water Facility Plan recommended that the City consider the following improvements to increase Malben-Woolston and Valley Zone storage capacity:

- Modify TMTP backwash and surface wash pumping to maximize clearwell storage volume. This would add 1.1 MG.

- Construct a new 1.5 MG clearwell at the MRTP. This has been completed and the net increase in storage capacity over and above chlorine contact time is 0.75 MG. This additional volume is included in the evaluation presented above.
- Modify the Dalhausen pump station so that the entire Malben Reservoir volume is active. This would add 1.3 MG.
- Woolston reservoir related improvements including modifying operation of the TMTP, modifying Reeder's Village Pumping Station to be able to pump out of the Woolston No. 2 Reservoir, raising the roof and walls, or constructing a taller reservoir to replace the Woolston No. 2 Reservoir. This could add 3.1 MG of storage.
- Construct additional storage in the Lower Malben-Woolston Zone.
- Construct a Westside Reservoir. This has been completed and has a capacity of 0.50 MG. This additional volume is included in the evaluation presented above.

The backwash and surface wash pumping facilities at the TMTP could be modified to maximize usable clearwell storage volume by constructing a means to pump water from the clearwell to the backwash wetwell in the event the clearwell level is drawn down to meet system demand. Modification of the Dalhausen Pumping Station would require major modification of the existing pumping station or construction of a new pumping station. Modifying the TMTP operation to maximize the Woolston No. 2 Reservoir would result in all reservoirs in the Upper Malben/Woolston Zone being drawn down below their normal operating level making the system vulnerable to inadequate storage during emergency conditions. Constructing storage in the Lower Malben-Woolston Zone would benefit operations because the low zone pumps could operate on reservoir level instead of pumping into a closed system. This would eliminate recycling water back to the wetwell which is inefficient and wastes energy and would provide lower, more constant system pressures, alleviating the challenges of balancing operation of the Low Zone Pumping Station and system PRV's. Operating at a lower system pressure would also reduce energy costs associated with low zone pumping. As demand in the Lower Malben-Woolston and Valley Zones increases, and the MRTP is used more, this will become even more desirable.

If the TMTP clearwell volume can be maximized, the required volume in the Lower Malben-Woolston and Valley Zones could be reduced to 3.0 MG. The operational benefits of having a Lower Malben-Woolston reservoir and pumping station outweigh the benefit of modifiying the Dalhausen Pumping Station or maximizing the Woolston No. 2 Reservoir volume, especially if the City plans on "reversing the roles" of the MRTP and TMTP thus utilizing the MRTP more in the future.

Feasible sites for locating a Lower Malben-Woolston Reservoir and Pumping Station were evaluated. Feasible sites included the Henderson Stormwater Ponds, Batch Fields, City owned property near the airport, the wastewater treatment plant (WWTP) site, and property adjacent to I-15 southeast of the intersection of I-15 and Highway 12. Design criteria used in evaluating the reservoir are summarized in Table 4-7.

Table 4-7 - Lower Malben-Woolston Reservoir Design Criteria

Description	Design Criteria
Lowest Pressure Zone Demand Elevation	3770 FT
Maximum Pressure Zone Demand Elevation	3962 FT
Minimum Desired System Pressure	30 psi
Low Water Elevation in Reservoir	4031 FT
Operating Depth	25 FT
High Water Elevation in Reservoir	4056 FT
Freeboard to Top of Tank	3 FT
Maximum Water System Pressure	124 psi
Reservoir Volume	3.0 MG

Figure 4-1 depicts the location of the reservoir sites evaluated. Criteria considered in evaluating reservoir sites included system pressure, fire flow, water age/quality, energy usage, property ownership, airport impact, cost, constructability, compatibility with other infrastructure, compatibility with growth, security, community acceptance, impact to adjacent property, and maintenance. The following text provides an evaluation of each reservoir site considered.

Wastewater Treatment Plant

Locating the new Lower Malben-Woolston Zone reservoir at the WWTP site would be advantageous with regard to connecting to the existing 20-inch MRTP transmission main. The ground elevation in the proposed area is 3810 feet which would require construction of an elevated tank with an overall height of 249 feet. Constructing an elevated tank to this height would be significantly more expensive than the other tank sites considered. In addition recent hotel development in the area would make public acceptance of an elevated tank at this site difficult to overcome. This site was not considered further due to these limitations.

Airport

Locating the new reservoir on the City owned property south of the Airport would eliminate the cost of purchasing property for the facilities. The site is in close proximity to the MRTP high zone transmission main which would minimize the cost of interconnecting piping. However, the site's proximity to the airport is an issue. The ground elevation at this site would require construction of an elevated tank with an overall tank height of 145 feet. The top of tank elevation would be 4059 feet. Discussions with the FAA's Helena District Office revealed that at this elevation and proximity to the airport, the reservoir would penetrate the north/south runway approach elevation. FAA would not be able to permit the site for construction of the reservoir. This site was not considered further due to this limitation.

Henderson Ponds

Locating the new reservoir at the Henderson stormwater pond site would require construction of an elevated tank with an overall height of 159 feet. This site would require minimal piping to tie into the Lower Malben-Woolston and Upper Malben-Woolston pressure zones and it would be a good location for a low zone to high zone pumping station. This site was evaluated using the system hydraulic model

for impact to system pressure, fire flow, and water age/quality under all treatment plant operational scenarios and existing and future conditions.

The model showed that locating the tank at this site would reduce pressures in a significant portion of the Lower-Malben Zone which is advantageous since pressures in portions of this zone are undesirably high. Fire flow is improved north of Custer and on the north end of Washington Street near the airport. Fire flow is decreased in the central portion of the zone due to the size of the main in Custer and a lack of system looping in this area.

Water age/quality is affected more by system operation than the location of the reservoir itself. Water age/quality can very greatly depending on which treatment plant is on-line and how low zone and high zone pumping is operated. For instance, the best Lower Malben-Woolston Zone water age is with the MRTP operating, the TMTP shut down, and low zone to high zone pumping from the Henderson Ponds reservoir site. This however, results in the worst Upper Malben-Woolston Zone water age. The best Upper Malben-Woolston Zone water age is with the TMTP operating, the MRTP shut down, and water flowing from the upper zone to the lower zone through the PRV's. Water age, with both treatment plants operating, results in an average condition in both the upper and lower zones.

Energy usage, especially during the summer months, would be reduced by constructing a Lower Malben-Woolston Reservoir. Construction of the reservoir would eliminate wasted energy usage due to water cycling from the discharge of the low zone pumps back to the wetwell. Reduced operational pressures in the lower zone would reduce low zone pump head conditions and energy demand. It would also minimize the amount of low zone to high zone pumping that would occur since all of the storage for the Lower Malben-Woolston zone is in the Upper Malben-Woolston zone.

The Henderson Pond site is owned by Lewis and Clark County. The City would need to acquire an easement from the County, jointly own or negotiate purchase or transfer of ownership of the property with the County.

FAA notice is required if a structure is within 20,000 feet of a runway and the height of the structure exceeds a 100:1 surface plane. The Henderson Pond site is approximately 14, 500 feet from the end of the runway at the Helena Airport so FAA notice would be required. The runway elevation is approximately 3862 feet and the tank height is estimated to be at an elevation of 4059 feet so the 100:1 surface plane would be exceeded by the tank. A siting study would be required but there is a reasonable chance that the tank site is approvable by FAA.

Figure 4-2 provides a schematic of how a tank and pump station at this location would tie into the existing system. The estimated cost of an elevated tank at this location is $4.7 million. Infrastructure improvements needed to tie the tank into the system would cost approximately $100,000 and a pump station built into the base of the elevated tank would be approximately $600,000. Other piping improvements to optimize locating a tank at this location would cost approximately $2.1 million and would consist of upsizing piping in Custer Avenue. Upsizing the pipe in Custer Avenue was identified as a recommended capital project in the 2005 Water Facility Plan. Cost associated with upsizing the piping in Custer includes replacing the existing 12-inch main with a 20-inch main.

Batch Fields

Locating the new reservoir at the Batch Fields site would require construction of an elevated tank with an overall height of 119 feet. This site would require minimal piping to tie into the Lower Malben-Woolston and Upper Malben-Woolston pressure zones, however; it would require relocating the PRV on N. Benton Avenue to allow connection of the reservoir to the upper pressure zone without installing piping across the railroad tracks. The Batch Fields site would be a good location for a low zone to high zone pumping station, similar to the Henderson site. This site was evaluated using the system hydraulic model for impact to system pressure, fire flow, and water age/quality under all treatment plant operational scenarios and existing and future conditions. The results of the modeling were very similar to the Henderson tank site.

The model showed that locating the tank at this site would reduce pressures in a significant portion of the Lower-Malben Zone which is advantageous since pressures in portions of this zone are undesirably high. Fire flow is improved north of Custer and on the north end of Washington Street near the airport. Fire flow is decreased in the central portion of the zone due to the size of the main in Custer and a lack of system looping in this area.

Water age/quality for the Batch Fields site would be similar to the Henderson Ponds site.

Energy usage for the Batch Fields site would be similar to the Henderson Ponds site.

The Batch Fields site is owned by the City, eliminating the need for easement acquisition or property purchase.

FAA notice is required if a structure is within 20,000 feet of a runway and the height of the structure exceeds a 100:1 surface plane. The Batch Fields site is approximately 10, 500 feet from the end of the runway at the Helena Airport so FAA notice would be required. The runway elevation is approximately 3862 feet and the tank height is estimated to be at an elevation of 4059 feet so the 100:1 surface plane would be exceeded by the tank. A siting study would be required but there is a reasonable chance that the tank site is approvable by FAA.

Figure 4-3 provides a schematic of how a tank and pump station at this location would tie into the existing system. The estimated cost of an elevated tank at this location is $4.4 million. Infrastructure improvements needed to tie the tank into the system would cost approximately $100,000 and a pump station built into the base of the elevated tank would be approximately $600,000. Other piping improvements to optimize locating a tank at this location would cost approximately $3.2 million and would consist of upsizing piping in Custer Avenue and in N. Benton Avenue from the tank to Custer Avenue with a new 20-inch main. Upsizing the pipe in Custer Avenue was identified as a recommended capital project in the 2005 Water Facility Plan.

I-15

Locating the new reservoir at the I-15 site has advantages and disadvantages in comparison to the other alternatives discussed above. Because the I-15 site is at a significantly higher elevation than the other sites a conventional buried or at grade tank could be constructed. This site is in close proximity to the

MRTP high zone transmission main which would minimize the cost of interconnecting piping and reduce pressures in the transmission main. However, it would also require modifying the new high service pumps at the MRTP to become low service pumps and construction of a new low zone to high zone pumping station at the tank site. In addition, optimization piping including connecting the discharge of the new high zone pumping a considerable distance to the 20-inch cross town connector and upsizing piping in Washington Street would be critical to making this tank location work. However, the interconnecting piping may be beneficial with regard to modifying the pressure zones. The I-15 site would not be the most optimal location for a high zone pumping station with regard to improving water quality and distribution and as was recommended in the 2005 Water Facility Plan, a high zone pumping station located somewhere on the west side of town would still be desirable. This site was evaluated using the system hydraulic model for impact to system pressure, fire flow, and water age/quality under all treatment plant operational scenarios and existing and future conditions.

Similarly to the other tanks sites evaluated, the model showed that locating the tank at this site would reduce pressures in a significant portion of the Lower-Malben Zone which is advantageous since pressures in portions of this zone are undesirably high. In addition, piping improvements necessary for implementation of this alternative would make it possible to modify the area bounded by the Airport to the north, I-15 to the east and Alice Lane to the south to be in the Lower Malben-Woolston pressure zone instead of the Upper Malben-Woolston pressure zone, eliminating high pressures in this area. It would also allow the MRTP high zone transmission main to be split, significantly reducing the high pressures experienced in this pipe. Fire flow is improved north of Custer and east of McHugh Lane but is decreased west of McHugh Lane.

Water age/quality, as was the case with the other tank sites, is affected more by system operation than the location of the reservoir itself. The best Lower Malben-Woolston Zone water age is with the MRTP operating, the TMTP shut down, and low zone to high zone pumping from the I-15 reservoir site. This however, results in the worst Upper Malben-Woolston Zone water age but it is better than the Henderson and Batch Fields site. The best Upper Malben-Woolston Zone water age is with the TMTP operating, the MRTP shut down, and water flowing from the upper zone to the lower zone through the PRV's. This does result in the worst water age conditions in the Lower-Malben Woolston Zone, even more so than the Henderson or Batch Fields sites. Water age, with both treatment plants operating, results in an average condition in both the upper and lower zones with slightly longer water age conditions in the Lower Malben-Woolston Zone than the Henderson and Batch Fields sites.

Energy usage, especially during the summer months, would be reduced by constructing a Lower Malben-Woolston Reservoir. Construction of the reservoir would eliminate wasted energy usage due to water cycling from the discharge of the low zone pumps back to the wetwell. Reduced operational pressures in the lower zone would reduce low zone pump head conditions and energy demand. It would also minimize the amount of low zone to high zone pumping that would occur since all of the storage for the Lower Malben-Woolston zone is in the Upper Malben-Woolston zone.

There are several properties that may be able to accommodate the I-15 site. They are owned by the Montana Department of Transportation and Padbury Ranch Properties LLC. The City would need to purchase property for the facilities or acquire an easement.

FAA notice would not be required for a tank at this site since it would be at grade or buried.

Figure 4-4 provides a schematic of how a tank and pump station at this location would tie into the existing system. The estimated cost of a tank at this location is $2.7 million. Infrastructure improvements needed to tie the tank into the system would cost approximately $1.1 million and includes a 20-inch main from the tank to the 20-inch cross town connector. A pump station would be constructed at the tank site and would cost approximately $800,000. Other piping improvements to optimize locating a tank at this location would cost approximately $2.9 million and would consist of upsizing piping in Washington Street and Cedar Street to 20-inch and would include a new 20-inch crossing of I-15. Piping improvements in Washington and Cedar Streets were recommended as capital projects in the 2005 Water Facility Plan. This alternative would not include a Low zone to high zone pumping station on the west side of the City as was recommended by the 2005 Water Facility Plan as the Henderson Ponds and Batch Fields alternative would. The estimated cost of this additional pumping station is 800,000.

Modification to the Missouri River High Zone Pumping Station would be required for implementation of this alternative. The existing high zone pumps could be modified by removing bowls from the pumps to meet the low zone head conditions. Examination of the pump curves shows that removing two bowls from the existing pumps would meet the low zone head conditions. The horsepower requirements of the pumps would be 400 HP. The existing pumps have 600 horsepower motors. Two of the pumps have variable frequency drives and could operate without replacing the existing motors. The third constant speed pump would likely need to have its motor replaced or a variable frequency drive added in order to function properly. There is sufficient space in the existing Missouri River high zone pumping station to add pumps to meet future demands. One additional pump would be required to meet predicted 2025 demand and another additional pump would be required to meet predicted 2045 demand. This assumes that the existing low zone pumps are kept in service.

Water Age, Pressure, and Energy Summary

Water Age

Water age/quality is affected more by system operation than the location of the reservoir itself. Water age/quality can vary greatly depending on which treatment plant is on-line and how low zone and high zone pumping is operated. For instance, the best Lower Malben-Woolston Zone water age is with the MRTP operating, the TMTP shut down, and low zone to high zone pumping from the Batch Fields reservoir site. This however, results in the worst Upper Malben-Woolston Zone water age. The best Upper Malben-Woolston Zone water age is with the TMTP operating, the MRTP shut down, and water flowing from the upper zone to the lower zone through the PRV's. Water age, with both treatment plants operating, results in an average condition in both the upper and lower zones. Water age summaries are included for both the Batch Fields and I-15 options at 2025 Average Day Demands in Table 4-8.

Table 4-8 - Reservoir Alternative 2025 Average Water Age Comparison Summary

Tank Alternative	TTP/MRTP		MRTP Only	
	Low Zone Average Age (hours)	Upper Zone Average Age (hours)	Low Zone Average Age (hours)	Upper Zone Average Age (hours)
No Modification	93	220	175	267
Batch Fields	101	197	127	234
I-15	44	106		

Pressure

The hydraulic model was used to evaluate the effects of having a Lower Malben-Woolston Zone tank. When the MRTP and Low Zone Pumping Station are not operating, water is fed from the Upper Malben-Woolston Zone to the Lower Malben-Woolston Zone through pressure reducing valves. The average pressure in the low zone is approximately 102 psi with over 50% of the zone between 90 and 135 psi. Maximum pressures exceed 160 psi in limited areas. These conditions are graphically depicted by Figure 4-5.

When the MRTP and Low Zone Pumping Station are operating, the pressure conditions worsen. The average pressure in the low zone increases to 110 psi with much of the area north of Custer Avenue between 135 and 160 psi. Maximum pressures exceed 160 psi in limited areas. These conditions are graphically depicted by Figure 4-6.

Adding a Lower Malben-Wooston Zone tank significantly improves the pressure conditions in the low zone. The average pressure in the low zone without the MRTP and Low Zone Pumping Station operating is reduced to 75 psi. System pressure throughout most of the low zone would be between 30 and 90 psi. Some portions of the system north of Custer Avenue would be between 90 and 135 psi. Maximum pressures would exceed 160 psi but only on the low zone to high zone transmission main. Adding a high zone pumping station at the I-15 tank location would eliminate this high pressure condition. These conditions are graphically depicted by Figure 4-7.

Pressure conditions with the MRTP and Low Zone Pumping Station operating and a low zone tank are similar to the conditions without the MRTP operating. Average pressures throughout the low zone are slightly higher, 78 psi. These conditions are graphically depicted by Figure 4-8.

Energy

The most cost effective operational scenario for the Helena water system is to have the TTP provide all of the water and not have to use the MRTP. This is possible in the winter months when demand is low but not during the summer months when demand is high. As the City grows and demand increases, the MRTP will need to be used more.

Energy usage, especially during the summer months, would be reduced by constructing a Lower Malben-Woolston Reservoir. Construction of the reservoir would eliminate wasted energy usage due to water cycling from the discharge of the low zone pumps back to the wetwell. This could also be reduced by installing automated controls on the low zone pump VFD's. It would also minimize the amount of low zone to high zone pumping that would occur since all of the storage for the Lower Malben-Woolston zone is in the Upper Malben-Woolston zone. The model was used to calculate energy usage under the different operational scenarios and with the Lower Malben-Woolston tank in service. The Lower Malben-Woolston tank would result in an energy savings of approximately $200 dollars a day under max month operating conditions.

Lower Malben-Woolston Zone Tank Evaluation Summary

Table 4-9 provides a comparison of reservoir alternative costs including connector piping, pumping, and pipe optimization components.

Table 4-9 - Reservoir Alternative Cost Comparison Summary

Project Element	Henderson Ponds	Batch Fields	I-15
Tank	$4,680,000	$4,360,000	$2,730,000
LZ to HZ Booster Pumping	N/A	N/A	$800,000
MRTP HZ Pumping Modifications	N/A	N/A	$50,000
Connector Piping	$100,000	$100,000	$1,110,000
Base Project Cost	**$4,780,000**	**$4,460,000**	**$4,690,000**
Pipe Optimization	$2,100,000	$3,200,000	$2,900,000
West Side LZ to HZ Booster PS	$600,000	$600,000	$800,000
Total Project Cost	**$7,480,000**	**$8,260,000**	**$8,390,000**

Each reservoir site was evaluated on a scale of 1-10, ten being the best and one being the worst, for each of the evaluation criteria including system pressure, fire flow, water age/quality, energy usage, property ownership, airport impact, cost, constructability, compatibility with other infrastructure, compatibility with growth, security, community acceptance, impact to adjacent property, and maintenance. Table 4-10 provides a summary of the evaluation.

Table 4-10 - Reservoir Evaluation Criteria Comparison

Reservoir Site	Pressure	Fire Flow	Water	Energy Usage	Property	Airport Impact	Initial Capital	Total Project	Constructabilit	Compatibility with other Infrastructure	Compatibility with Growth	Security	Community Acceptance	Impact to adjacent	Maintenance	**Total Points**
Henderson Ponds	7	8	5	5	6	9	7	8	7	8	7	8	5	4	6	**100**
Batch Fields	7	8	5	5	9	8	9	7	8	7	8	8	6	5	6	**106**
I-15	9	7	5	6	6	10	8	6	9	6	6	7	8	5	8	**106**

The evaluation shows that the three alternatives are extremely close in ranking, especially the Batch Fields and I-15 sites.

Woolston Tank Optimization

The Woolston reservoirs have available storage in emergency situations when the hydraulic grade line drops low enough which typically doesn't happen until flow from the TMTP is less than 2.5 MGD. The 2005 Water Facility Plan evaluated alternatives for improving usable storage in these reservoirs. Alternatives included:

- Assuring the TMTP operates at 2 MGD on a regular basis to allow the Woolston reservoirs to fill and draw.
- Pump out of Woolston No. 2 using Reeder's Village pump station.
- Raise the walls of the reservoirs or construct a new, taller reservoir.

Under predicted demand conditions, it is not feasible to limit the TMTP operation to 2 MGD on a regular basis. Pumping out of the Woolston tanks with the Reeder's Village pumping station results in a 120 day turnover rate which, from a water quality standpoint, is unacceptable. Raising the walls of the reservoirs or constructing a new reservoir would increase the usable capacity, however; it would cost at least as much as constructing new storage in the Lower Zone and would not be as efficient or benefit operation of the Low Zone pumping station as would a Low Zone tank.

The storage evaluation performed earlier in this chapter shows that if the TMTP backwash pumping is improved to allow more of the TMTP clearwell volume to be used, and storage is constructed in the Lower Zone, the Woolston reservoir storage is not needed.

Malben

The Malben reservoir is a 4.0 MG tank of which 2.7 MG is active. The 2005 Water Facility Plan evaluated options for achieving full utilization of the Malben reservoir and thus adding 1.3 MG of storage to the Upper Malben-Woolston Pressure Zone. The 2005 Water Facility Plan discussed constructing a new Dalhausen Pump Station designed to have sufficient suction conditions for proper operation of the pumps at the lowest level in the reservoir. A second set of pumps would provide a means to supply the Hale Zone. In addition a generator would be provided for backup power and to compensate for lack of storage in the Winne Zone. The cost of constructing a new Dalhausen Pump Station was estimated to be $1.2 million.

Additional storage in the Upper Malben-Woolston Zone is not needed if a Lower Malben-Woolston reservoir is constructed. Having storage in the Lower Malben-Woolston Zone is a much more efficient means of serving the Low Zone. It is not recommended that a new Dalhausen Pumping Station be constructed at this time simply to provide additional storage for the Lower Zone. Adding backup power to the Dalhausen Pump Station and increasing firm pumping capacity to 1,510 gpm would improve the reliability of the system to meet peak hour demands in the Winne Zone.

Hale

The Hale Zone was evaluated in the previous plan in light of operational concerns if both the Orofino and Eureka sources were removed from service. Currently, the zone is served by only the Eureka source as the Orofino source was classified as Groundwater under the Influence of Surface Water (GWUISW) in 2005 and removed from service. Based on production records and information provided by the City, the Eureka source has a difficult time keeping up with demands during peak demand periods and an alternative source for the Hale and Upper Hale Zones should be provided.

In lieu of continuing to supply the Hale Zones (Upper Hale and Hale) from Eureka, the Hale zones could be supplied from the Winne Zone, the Upper Malben-Woolston Zone or Reeder's Village. The following were evaluated and are shown in Figure 4-9.

1. **Winne Zone Connection.** The previous facility plan recommended extending an existing 12-inch waterline from the Winne Zone, (along the north side of Malben Reservoir) from Beattie and Rhode Island to Beattie and State Avenue. The new 12-inch was connected to the existing 10-inch at Beattie and State Avenue that leads back to the Hale Reservoir. A PRV was recommended, but an isolation valve was installed for this purpose. This connection is not currently active (the valve is closed). During a fire, this valve can be opened to provide an average of 800 gpm in additional flow to meet fire flow requirements.

2. **Upper Malben-Woolston Connection**. The previous facility plan recommended modifying the Dalhausen Pump Station to pump to the Hale Zone. Under this scenario, the 12-inch waterline north of Malben would be extended to the existing 10-inch leading to the Hale Reservoir as described above.

3. **Reeder's Village Connection.** The previous plan recommended running an 8-inch line from the Reeder's Village pressure zone to the discharge side of the Eureka Pump Station, which feeds the Hale Reservoir. A PRV is necessary at the connection point.

Ultimately implementing all three options offers the most redundant system. Option 1 is the simplest option and phases well with Option 2. Option 1 was partially completed as described above. Option 2 improves the energy efficiency. Option 3 would improve redundancy if Eureka is taken out of service or if Reeder's Village is tied into West Main for fire flow reasons.

Westside

The Westside storage tank and Forrest Estates pump station modifications were constructed and put into service in 2010. The pressure zone is still being defined, but is roughly bound by Le Grande Cannon Boulevard and University Street. While the improvements have improved pressures and brought fire flow availabilities into compliance, the large volume of storage and few connections is creating a water quality issue.

Some recommendations include expanding the pressure zone or connecting Reeder's Village to the Westside Pressure Zone.

Fort Harrison

The Fort Harrison system was evaluated to determine the most effective way to serve the system. The evaluation included the following:

- Capability of the City of Helena to serve the system under various operating scenarios currently and at 2025 demands including TTP alone, MRTP alone and with both plants operating. The evaluation included moving the system to the Lower Malben-Woolston pressure zone and constructing booster pumping facilities.
- Efficacy of backflow prevention infrastructure and recommended improvements

System History

The Fort Harrison water system is a consecutive system located at 3687 Veterans Drive in the northwestern portion of Helena. The system serves the Veterans Administration (VA) facility, Montana Army National Guard (Fort Harrison), and other branches of the federal government including the Naval Reserve Center and US Property and Fiscal offices. The system is master metered off of the City of Helena water system in two locations. While the Fort was established in 1892, the US Army Post left in 1913 and the Montana National Guard took over. The VA took over partial use of the Fort as a Hospital after World War I.

Fort Harrison consists of 8500 acres and varies in elevation from 3860 to 4360 feet above mean sea level. The water system consists of 3.5 miles of water line ranging in size from 4 inches to 12 inches. A 200,000 gallon storage tank with altitude valve serves the area.

Based on historical newspaper accounts, the water system was originally constructed in 1894. The account indicates:

> "*The water system extends from the city main at the Broadwater and furnishes water to the fire hydrants and all domestic services. There has been 14,218 feet of water pipe laid. Water for irrigation purposes will be taken from the springs in the hills on the reservation.*"

A schematic of the Fort Harrison system from the hydraulic model is shown in Figure 4-10.

Figure 4-10 - Fort Harrison System

Ability to Serve

The Fort Harrison distribution system was evaluated in light of the City of Helena's capabilities to serve the area. This included evaluating different plant operating scenarios and at different demand needs, including fire flow requirements. Our evaluation also included relocating the connection to the City's system to the Lower Malben-Woolston Zone.

The basis of planning for Fort Harrison is as follows:

Table 4-11 – Fort Harrison Basis of Planning Criteria

Project Element	Criteria
Current Maximum Day Demands (GPM)	283
Tank Minimum Level (HGL)	20 (4297)
Tank Maximum Level (HGL)	22 (4299)
Required Fire Flow Demand (GPM)	1,500
Observed Pressure at 12" line at meter vault (after backflow preventer) (psi)	150
Observed Pressure at 8" meter vault – Ground Level (psi)	160
Observed Pressure at 8" meter vault – Inside Vault (psi)	120-130

Preliminary findings indicate:

- Under the MRTP Only scenario, the average hydraulic grade (over a 24-hour period) within the Fort Harrison system is 4284 and the City is unable to maintain the minimum 20-foot level in the tank. However, fire flows within the system can be met with a residual pressure of 47 psi.

- Under the two plant scenario, the Fort Harrison tank is able to maintain the 20-foot minimum level necessary and adequate fire flow demands can be met with a residual pressure of 50 psi. The average hydraulic grade line over a 24-hour period is 4301.
- Under the Ten Mile only scenario, the average hydraulic grade line over a 24-hour period is 4331, well in excess of the tank's maximum grade line. The 1,500 gpm fire flow demand is met with a residual pressure of 58 psi.

The City's hydraulic model was utilized to evaluate a potential connection to the Lower Malben-Woolston Zone in lieu of the existing connection to the Upper Malben-Woolston Zone. The hydraulic grade of the Lower Malben-Woolston zone is well below the minimum level of the VA's existing tank at 4258.

Backflow Prevention

Based on our review of the system configuration, the rated flow of the existing backflow preventer is marginal for the demands under a fire flow scenario. Based on a typical Cla-Val double check backflow preventer, the 8-inch preventer has a rated flow of 1600 gpm. As demands increase in the Fort Harrison system, the 8-inch preventer should be replaced with a 10-inch model that will provide a rated flow of 2,400 gpm.

Recommendations

Based on our analysis, the following modifications are recommended:

- Replace the existing backflow preventer with a 10-inch model in order to provide a rated flow that can meet projected demand and fire flow requirements.
- Utilize a wider range of the tank's capacity. Pressures in the system ranging from approximately 150 to 120 psi are high. An operating range of 6 to 7 feet would provide sufficient fire storage for a 2 hour, 1500 gpm fire and would reduce operating pressures.
- Under maximum day demands operating the MRTP alone does not provide sufficient head to keep the Fort Harrison tank full. A booster pump station would be required to maintain sufficient enough pressure to fill the Fort Harrison Tank. At current maximum day demands, flows would require a 20-30-foot boost. At 2025 maximum day demands and only the MRTP operating, a boost of 65 feet would be necessary.
    - Since the TTP provides plenty of head to supply the system, a bypass should be installed as part of the booster pumping station with a PRV to reduce pressures to the Fort Harrison tank overflow hydraulic grade line and minimize booster pumping.
    - Additionally, the backflow preventer and master meter for the entire system could be relocated to a central location (in the booster pump station).

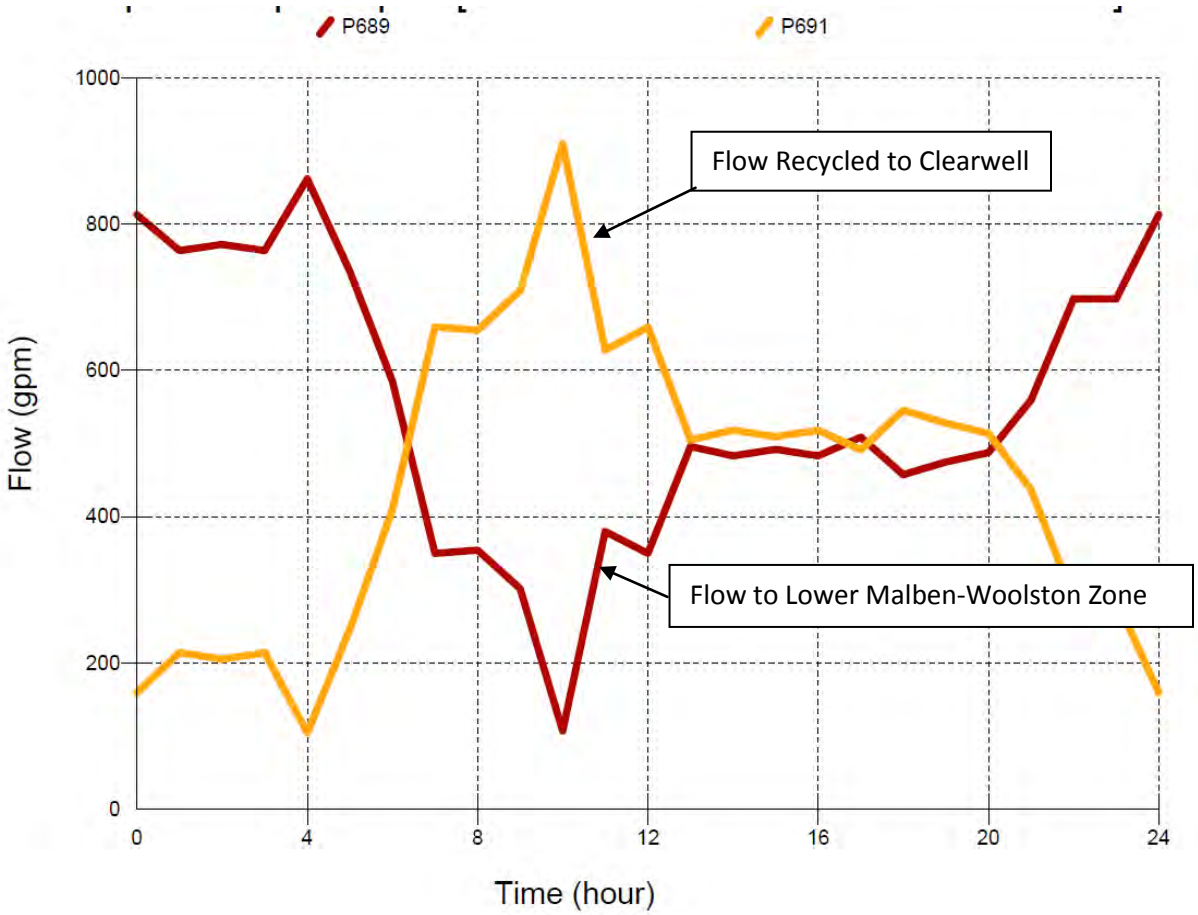
Lower Malben-Woolston Pumping

The Lower Malben-Woolston Pumping Station pumps water from the MRTP to the Lower Malben-Woolston pressure zone. Since there is not a tank in the low zone, the pumps pump against a closed

system. There is a pressure relief valve on the pumping system that relieves water back to the clearwell at discharge pressures above 170 psi.

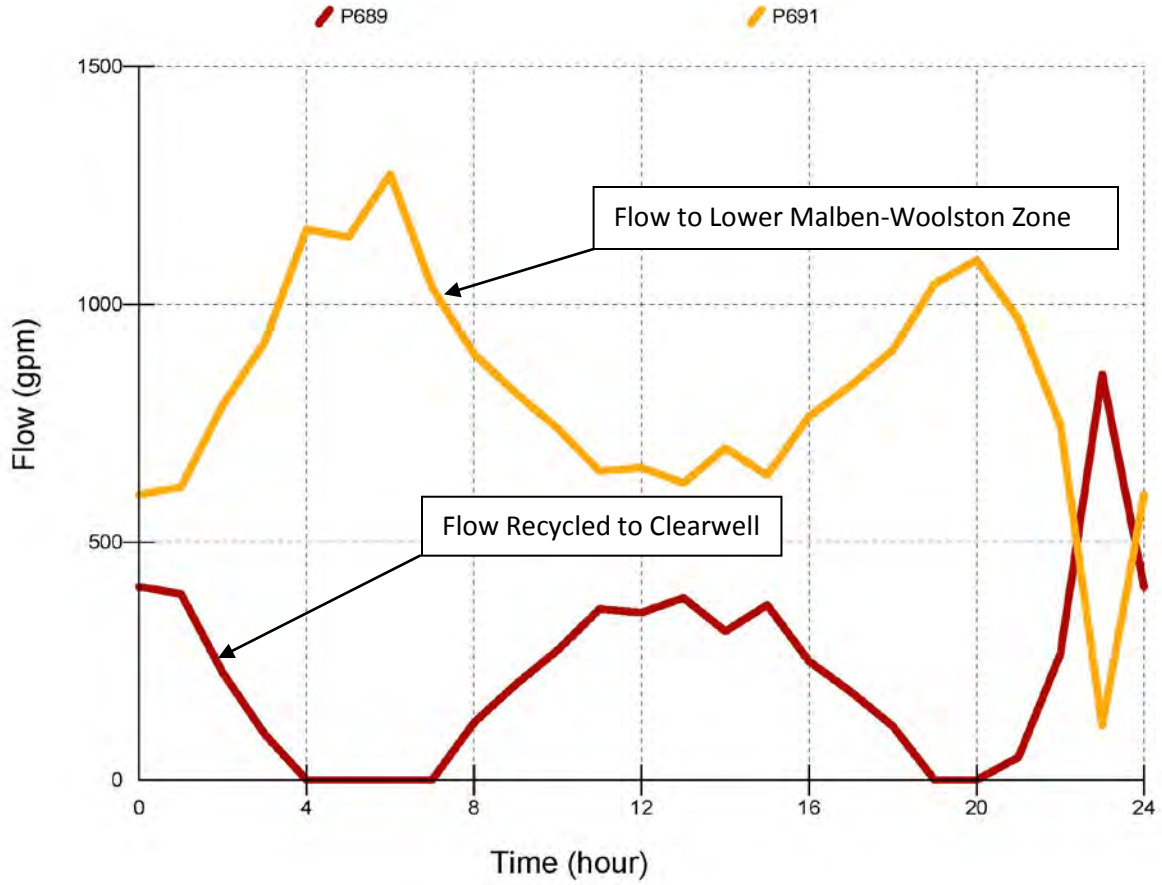
The smallest low zone pump is a 125 HP, constant speed, vertical turbine pump that can produce pressures as high as 230 psi at its shut off condition. During current minimum day demand periods the pump reaches 194 psi, much higher than the pressure setting on the PRV and water is recycled back to the clearwell. System pressures are in excess of 120 psi under these operating conditions. The hydraulic model shows that no water feeds into the low zone from the upper zone under these operating conditions. Figure 4-11 shows the water flow to the system and to the clearwell under minimum day demand conditions. As can be seen, under minimum day demand conditions, water is always released back to the clearwell. For reference, the zero hour is midnight.

Figure 4-11 - Low Zone Pumping - Minimum Day Demand



During current average day demand periods the pump reaches pressures in excess of the pressure setting on the PRV during part of the day and water is recycled back to the clearwell. The small pump can't meet all of the demand during part of the day and water is fed into the lower zone from the upper zone through PRV-1 on the far west side of the low zone. Demand above approximately 1,000 gpm is met by water from PRV-1. Figure 4-12 shows the water flow to the system and to the clearwell under average day demand conditions. As can be seen, under average day demand conditions, a significant amount of water is released back to the clearwell but there are periods of time when the PRV is closed.

Figure 4-12 - Low Zone Pumping - Average Day Demand



During current maximum day demand periods the smaller pump has only enough capacity to meet approximately half of the demand. The other half of the demand is met by water coming through the PRV's from the upper zone. No water is recycled to the clearwell under this operational scenario. Figure 4-13 shows the water flow to the system under max day demand conditions.

Figure 4-13 – Low Zone Pumping - Max Day Demand

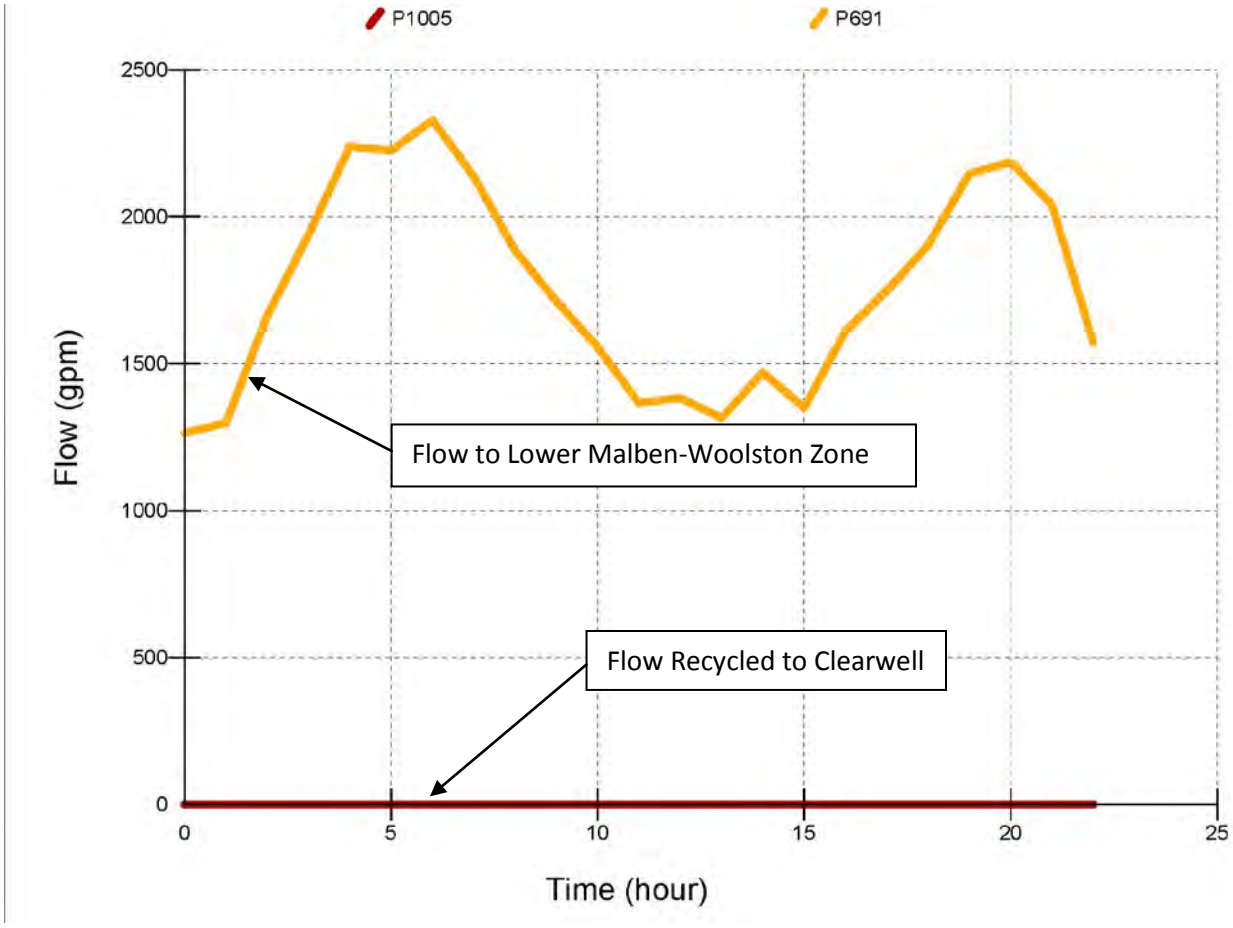


Table 4-12 summarizes the results of the analysis.

Table 4-12 - Low Zone Pumping Analysis Summary

Demand Scenario	Low Zone Pump Configuration	MRTP PRV Results	Distribution PRV Results
Min Day	Small Pump	Water Continuously Recycled	No Flow
Min Day	Small Pump W/VFD and Pressure Control set at 155 psi	No Water Recycled	Intermittent Flow at PRV-1, maximum of 65 gpm
Average Day	Existing Small Pump	Intermittent Recycle	Flow to meet demand above 1000 (+/-) gpm
Average Day	Large pump with VFD and Pressure /Control Set at 155 psi	No Recycle	No flow through PRV's
Max Day	Existing Small Pump	No Recycle	Approximately one half demand through PRV's
Max Day	Large Pump with VFD and Pressure Control Set at 155 psi	No Recycle	Approximately 300 gpm through PRV-1

Operation of the Low Zone Pumping system could be optimized by adding a VFD to the smaller pump and adding automatic pressure control for all pumps. System pressures could be reduced, recycle to the clearwell could be eliminated, and flow from the high zone to the low zone minimized.

If a VFD was added to the small pump it could match the minimum day demand with no recycle to the clearwell. The operation strategy would be to vary the pumps speed to maintain a discharge pressure setpoint. We utilized the hydraulic model to analyze different discharge pressure setpoints. A discharge pressure setpoint of 150 psi would result in a significant reduction in system pressure with the pumping station operating. The system would not recycle flow to the clearwell and a very minor amount of flow, 65 gpm, would feed through PRV-1 during the minimum day demand higher diurnal flows. If the larger, VFD driven pump is operated at the same discharge pressure setpoint, it can match the average day demand with no recycle flow to the clearwell and no water feeding into the low zone from the high zone. If the larger, VFD driven pump is operated at the 155 psi discharge pressure setpoint at max day demand, there is no recycle to the clearwell and 300 gpm is fed though PRV-1 to the lower zone during the maximum day demand higher diurnal flows. It may be possible to reduce the amount of flow coming from the upper zone to the lower zone by changing system PRV setpoints or increasing the discharge pressure setpoint depending on the desired system pressure.

Lower Malben-Woolston Pressure Zone Reconfiguration

One issue that the City of Helena faces more so than low system pressures are high system pressures. There are large portions of the distribution system that operate at pressures above 135 psi, primarily in an east-west corridor between Euclid Avenue and the railroad tracks on the western side of Helena and between Missoula and the tracks on the eastern side of town.

In order to lower pressures in this area, the boundary between the Lower and Upper Malben-Woolston Zones would need to be reconfigured. This reconfiguration would need to also take into account plant and transmission main capacities, location of key Upper and Lower Malben-Woolston infrastructure and ease of implementation.

The model was modified to reflect inactive PRVs 1 through 5, and closed pipes defining the pressure zone. Pressure constraints, based on City instruction, were set at 135 psi. Scenarios were constructed for existing, 2025 and 2045 maximum day demands. The other constraint on the analyses is the capacity of the Tenmile WTP and transmission main. The current transmission main capacity is on the order of 7.5 mgd, while treatment capacity at Ten Mile is 8.0 mgd.

Table 4-13 summarizes the adjusted demands.

Table 4-13 - Low Zone Pressure Reconfiguration (Existing System Boundary)

Demand Summary	Current Average Day	2025 Average Day	2045 Average Day
Low Zone Current	1.17	1.46	1.65
Low Zone Revised	1.93	2.63	2.98
Upper Zones [1] Current	3.87	4.79	5.45
Upper Zones [1] Revised	3.11	3.62	4.12

1. Upper Zones include Reeders Village, Westside, Winne, Hale and Upper Hale Zones in addition to the Upper Malben-Woolston Zone.

Based on the configuration, the revised pressure zone boundary would move south to approximately Euclid and Montana Avenues. Demands to be provided by Tenmile Treatment plant under existing maximum day conditions would be on the order of 8.2 mgd. Modifications to the TTP transmission main and control valve would need to be conducted, or supply would require supplementation from MRTP in order to supply maximum day demands. It should be noted that even through 2045, average day demands in the Upper Malben-Woolston Zone could be met by TTP without supplementation from MRTP.

One area complicated by a zone reconfiguration would be the High Zone discharge line from Missouri River WTP to the Nob Hill Reservoir. The portion of the system east of the 20-inch steel line would require PRVS and would remain in the Upper Malben-Woolston Zone. If the Lower Malben-Woolston tank is constructed at the I-15 site, the 20-inch steel line would become a lower zone line and the pressure zone boundary east of I-15 could be reconfigured. This is an added benefit to constructing the I-15 tank.

Figure 4-14 shows the area that would become part of the Lower Malben-Woolston Zone under this reconfiguration scenario.

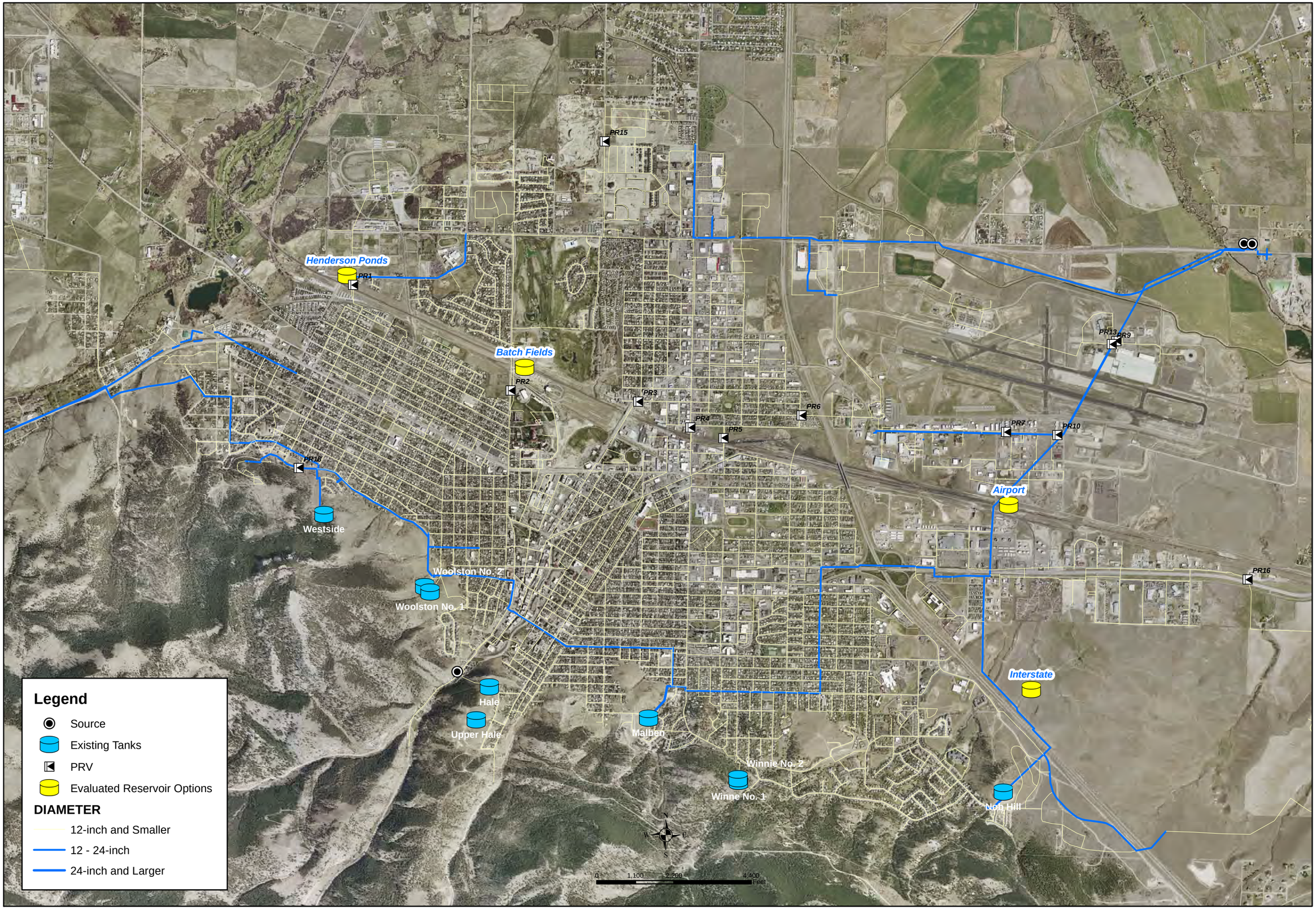


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Figure 4-1
Low Zone Reservoir Locations

May 3, 2011

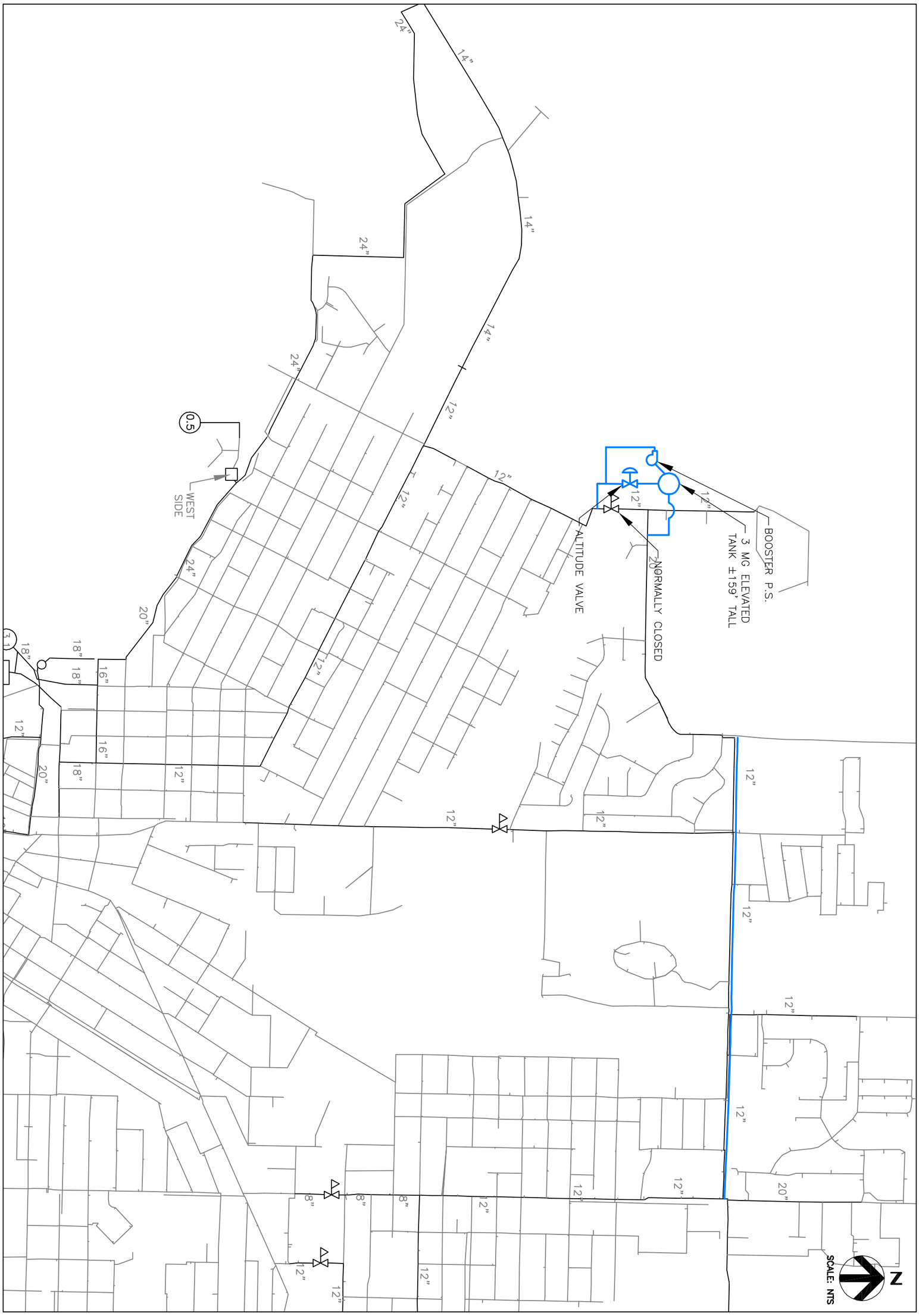

Figure 4-2
Low Zone Reservoir
Henderson Ponds
Alternative

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August 10, 2011

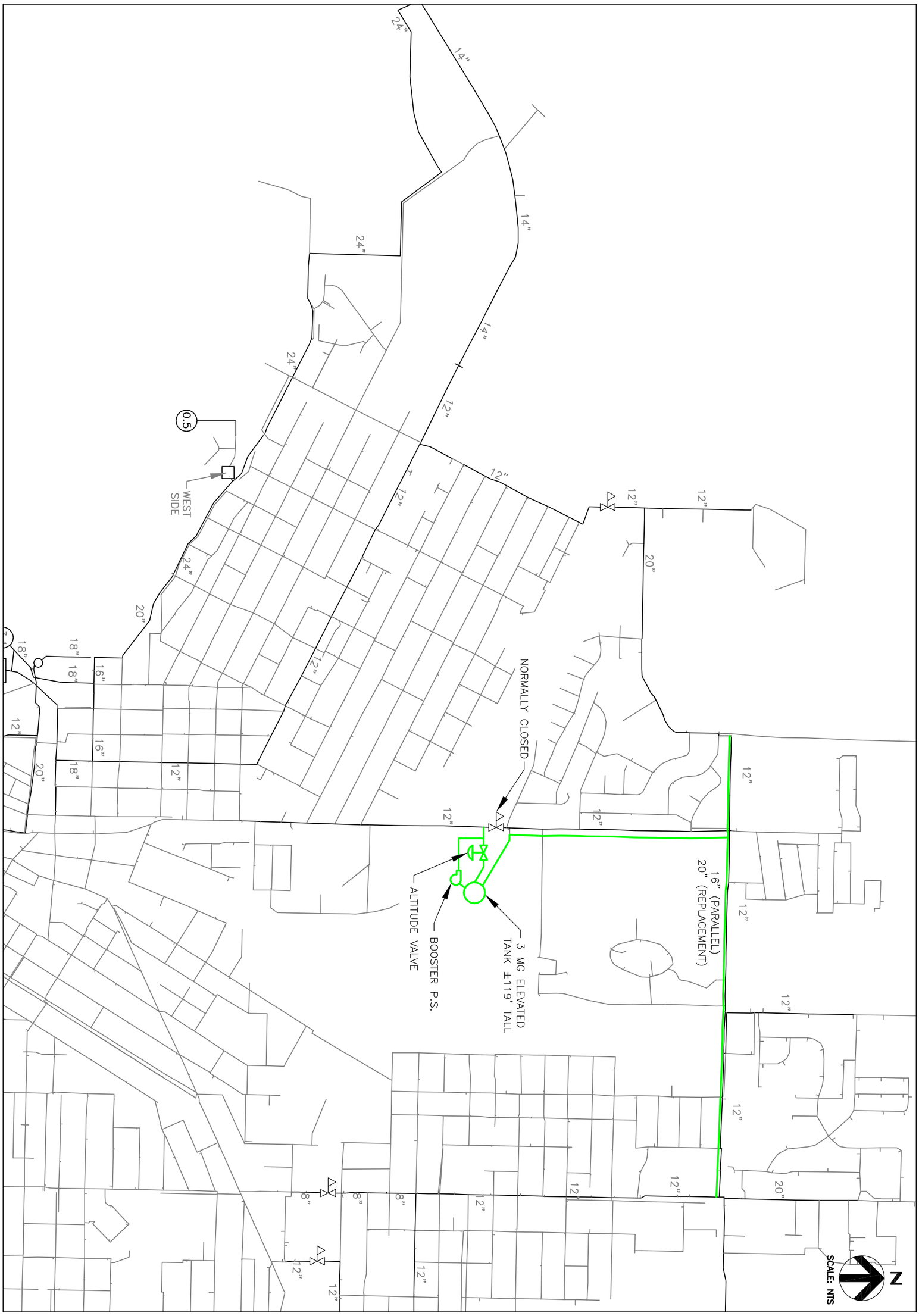

Figure 4-3
Low Zone Reservoir
Batch Fields
Alternative

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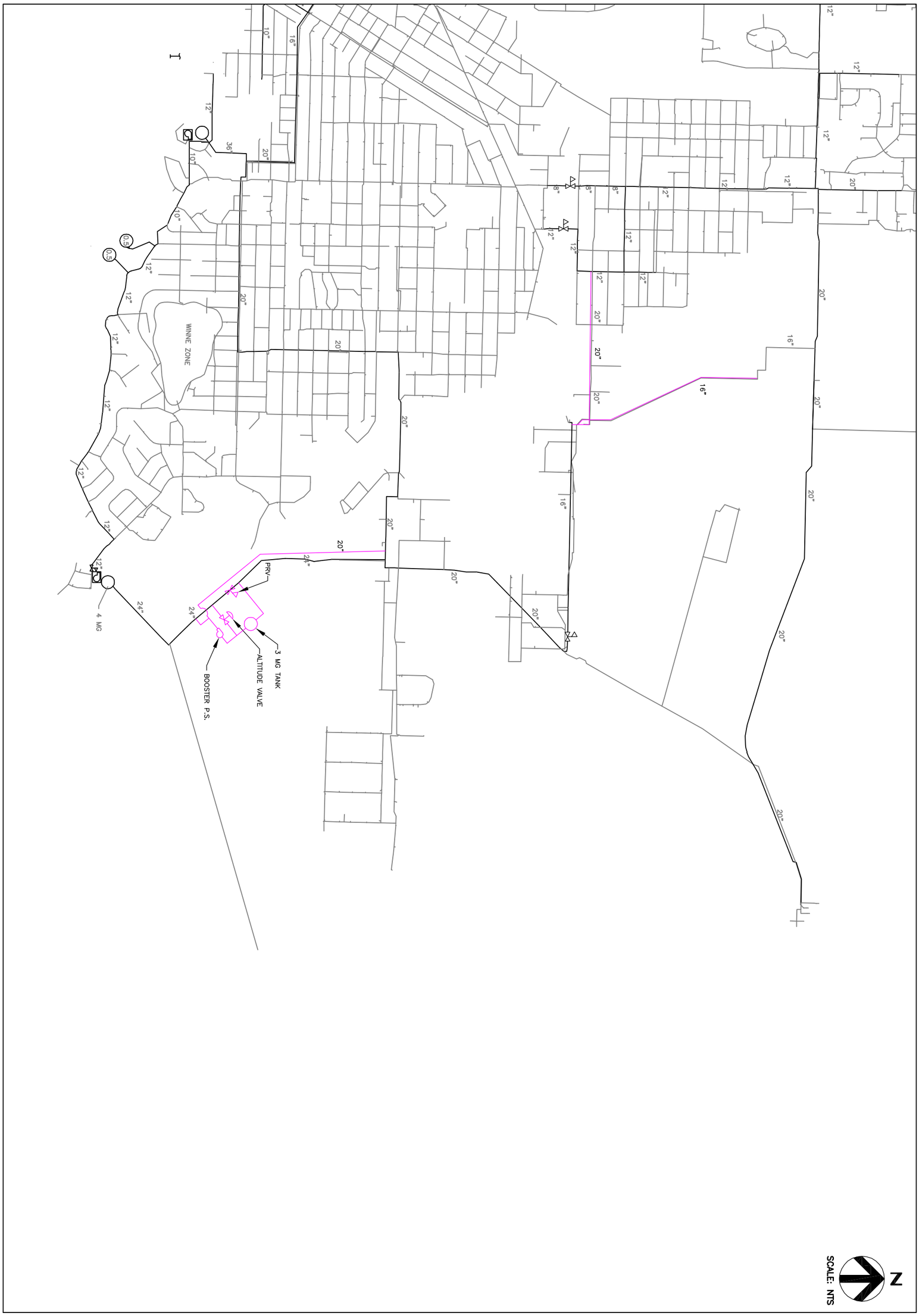

Figure 4-4
Low Zone Reservoir
Interstate Alternative

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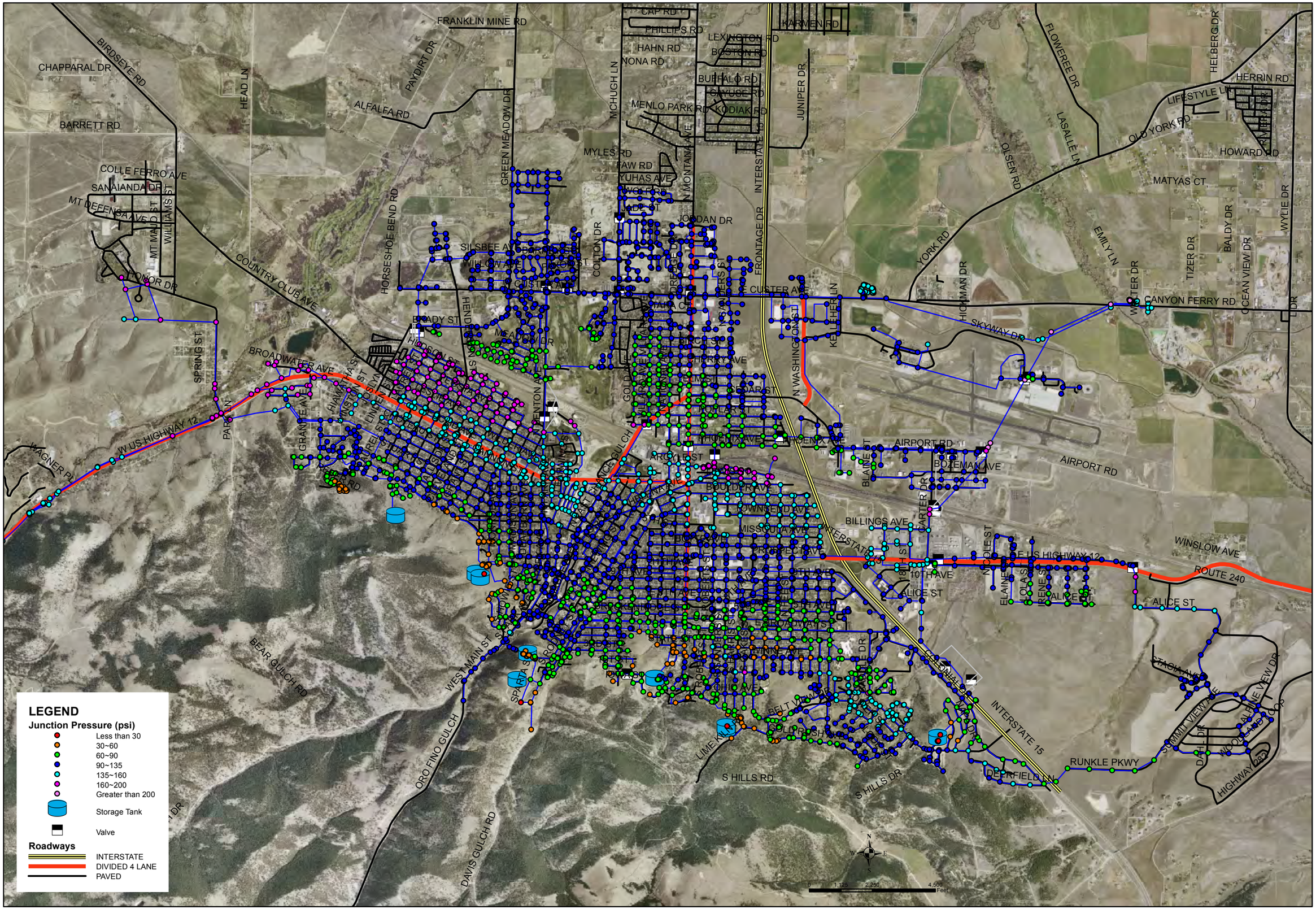

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Figure 4-5
Maximum Month Pressures
(No Tank and No MRTP Low Zone)

January 6, 2012

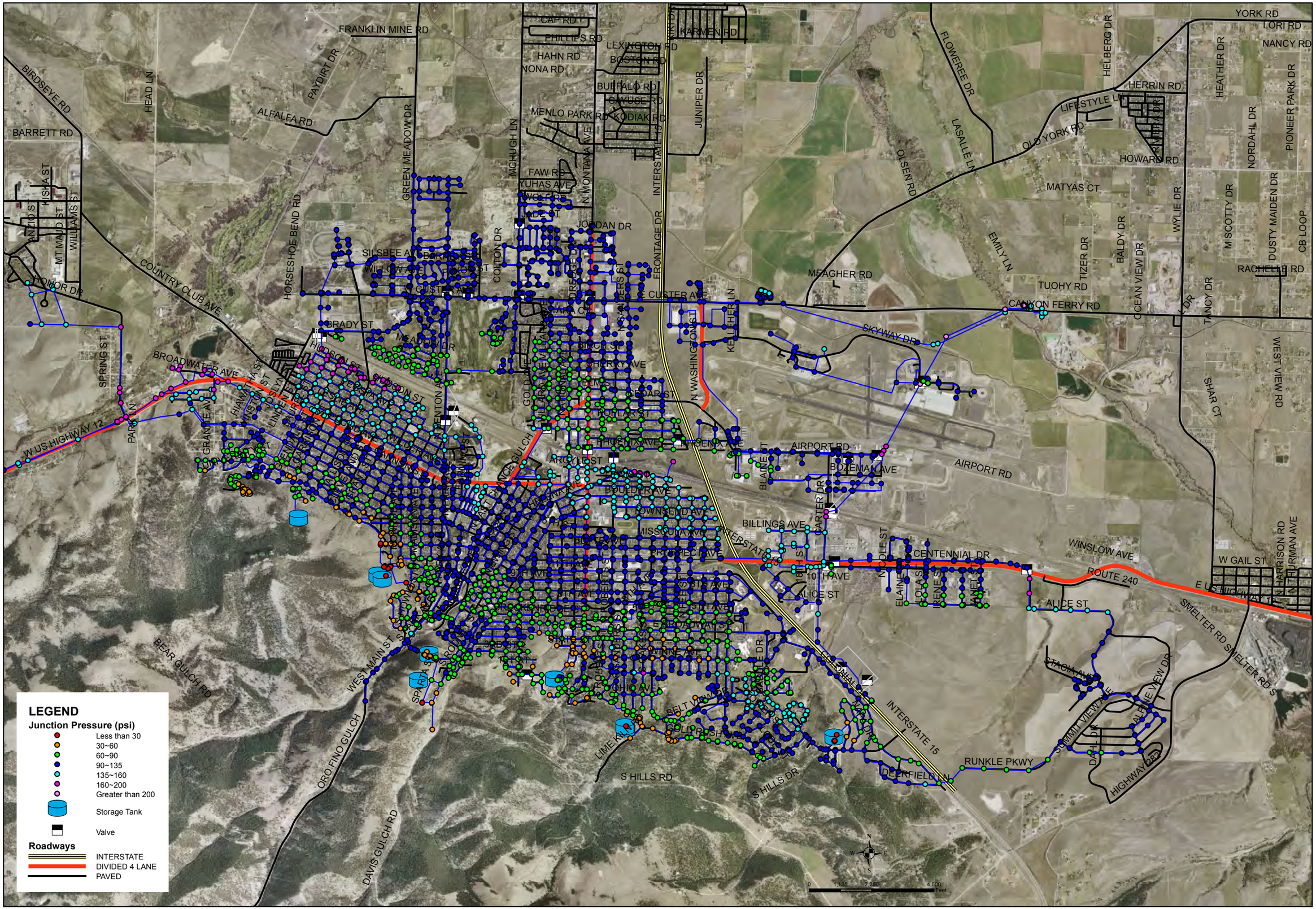

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Figure 4-6
Maximum Month Pressures
(Both Plants incl. MRTP Low Zone)

January 6, 2012

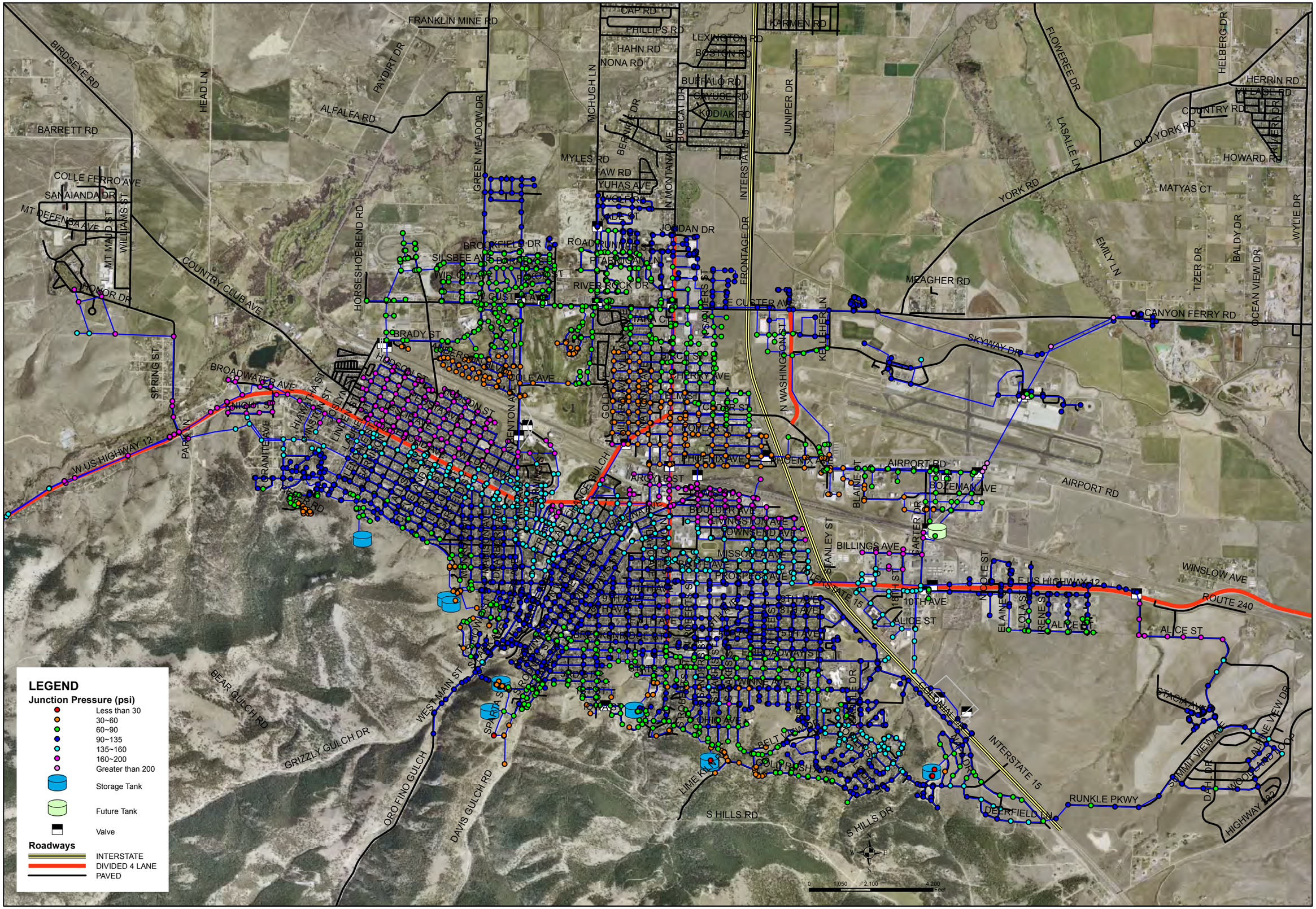

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Figure 4-7
Maximum Month Pressures
(Tank without Low Zone Operating)

January 6, 2012

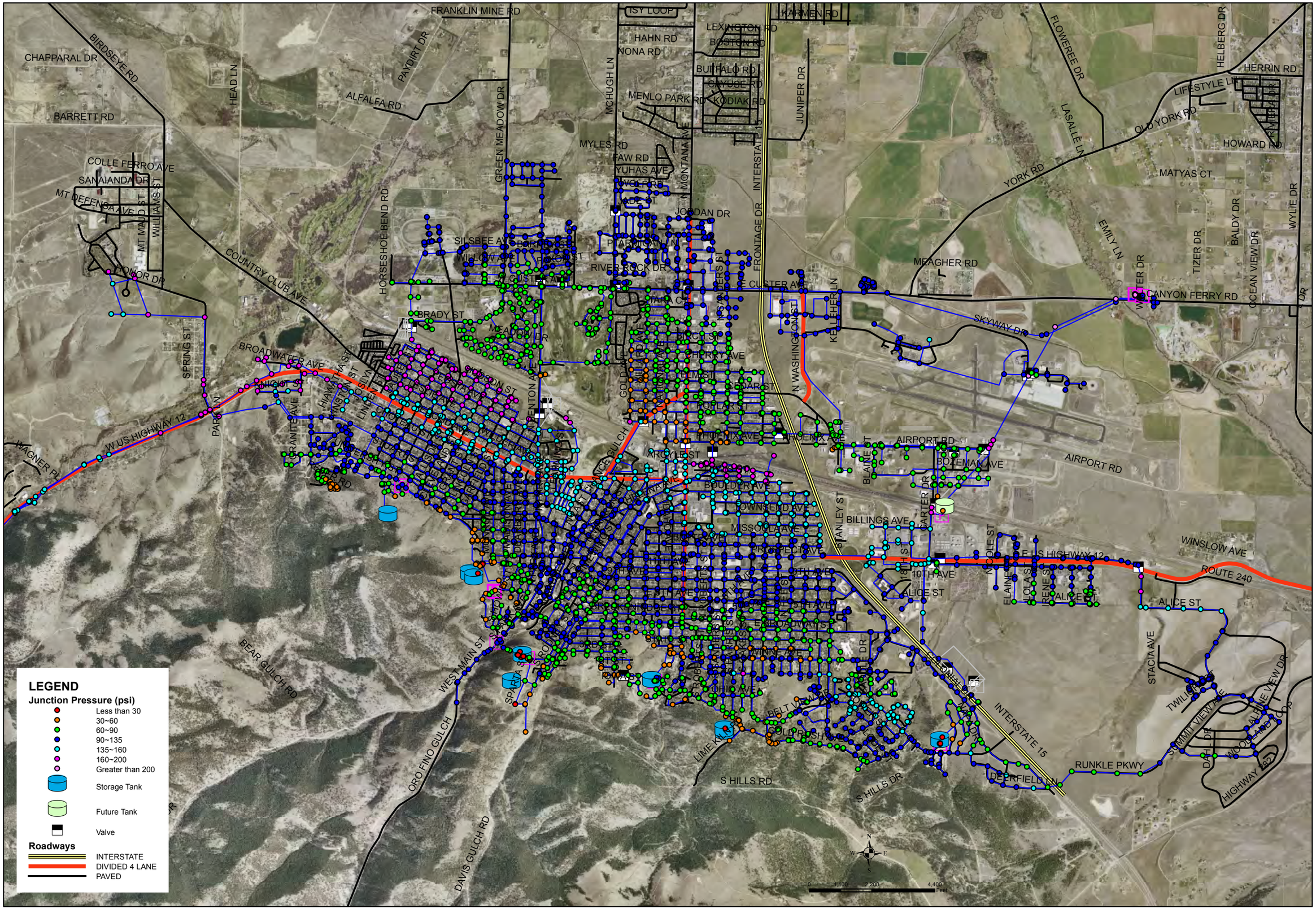

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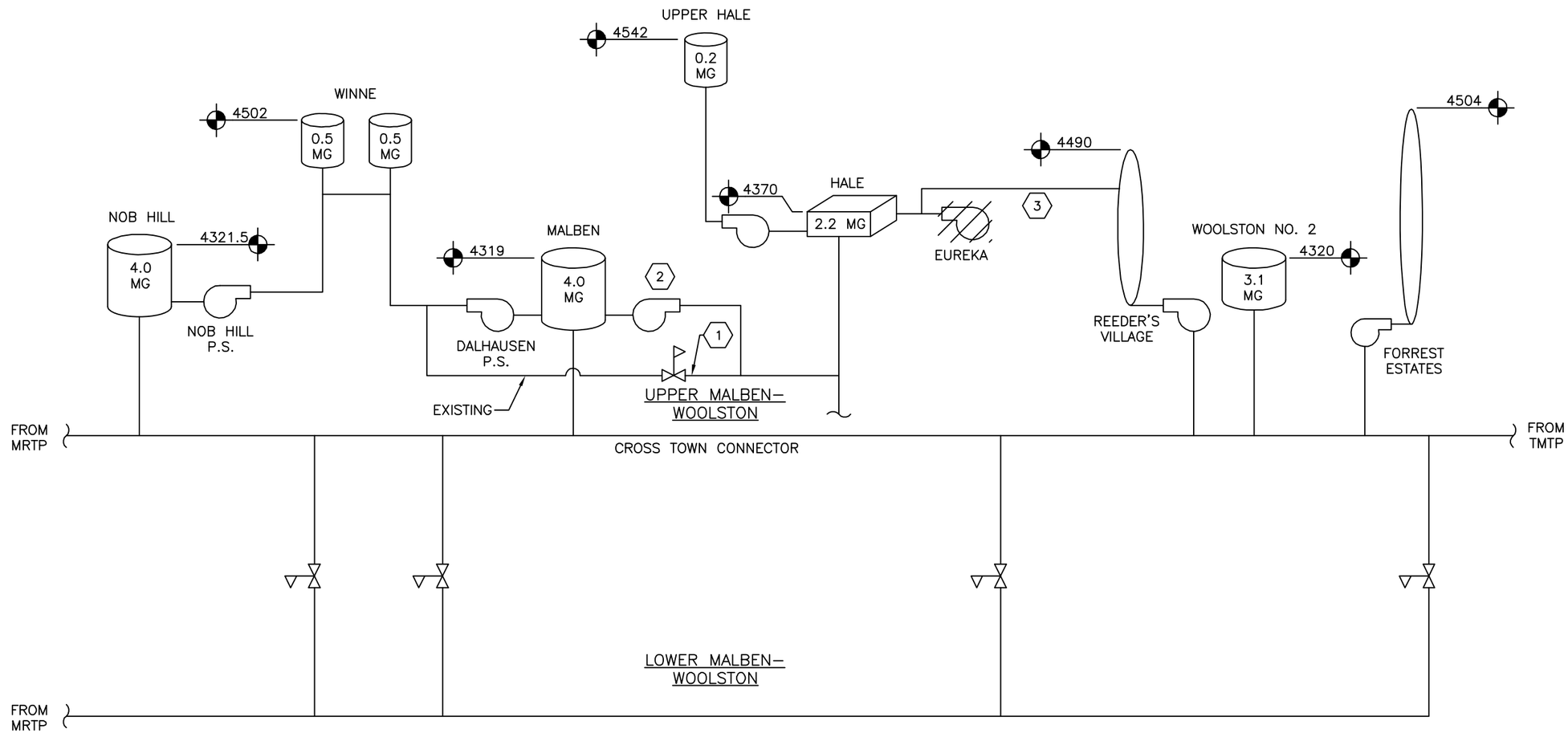
Figure 4-8
Maximum Month Pressures
(Tank with Low Zone Operating)

January 6, 2012



1. CONTINUE EXISTING 12–INCH LINE TO HALE ZONE AND PROVIDE PRV.
2. MODIFY DALHAUSEN P.S. FOR PUMPS TO SUPPLY HALE ZONE.
3. EXTEND SERVICE FROM REEDER'S VILLAGE TO EUREKA PUMP STATION.

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Figure 4-9
Hale Zone Alternate Supply Options

August 10, 2011

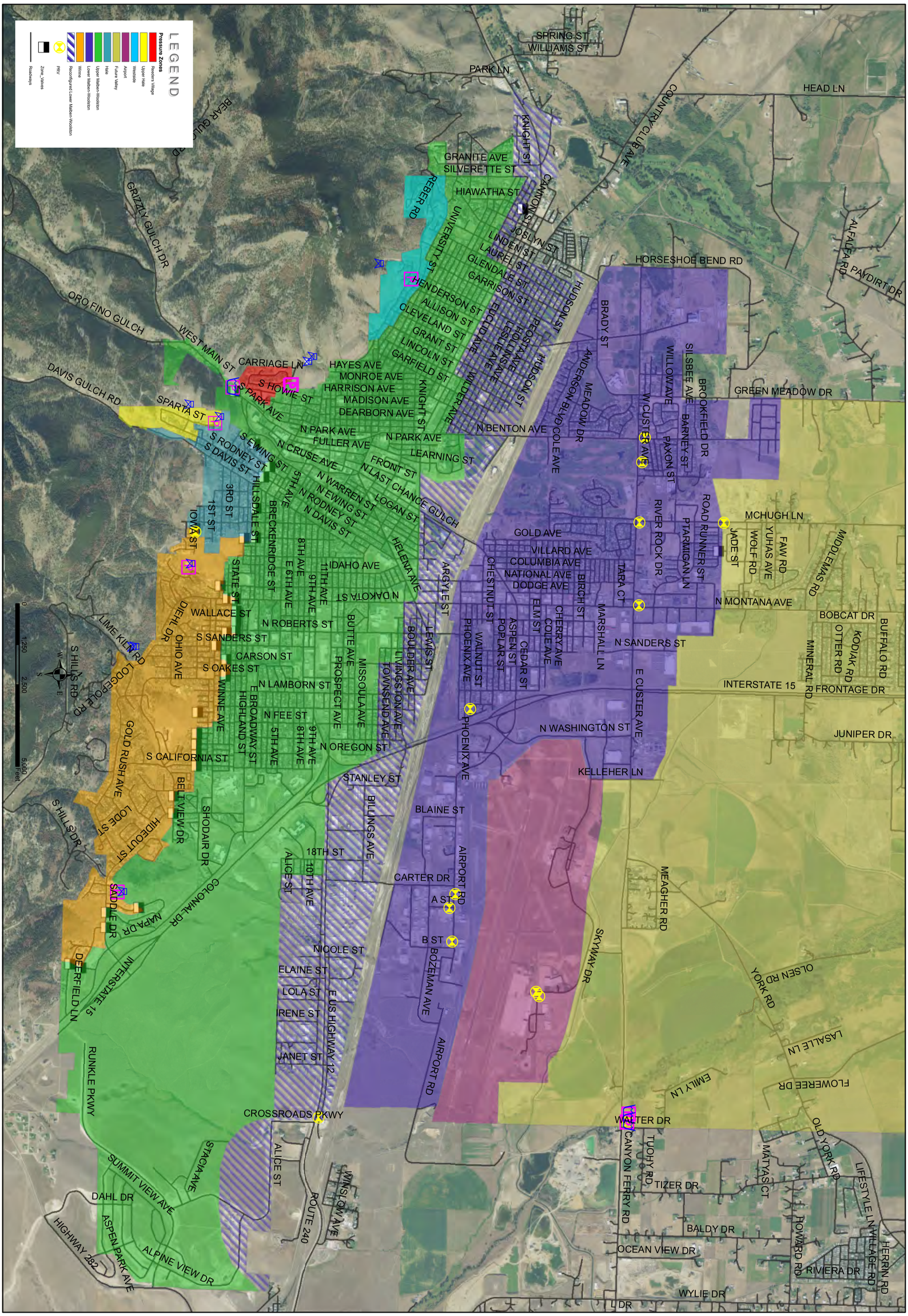

Figure 4-14
Future Pressure Zones

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January 6, 2012

Chapter 5: Treatment Plant Analysis and Comprehensive Performance Evaluation

Introduction

A Comprehensive Performance Evaluation (CPE) of the City of Helena's Missouri River Water Treatment plant and Tenmile Water Treatment Plant was performed by Crazy Mountain services, LLC and South Hills Consulting, LLP in 2009. This chapter provides a summary of the evaluation and resulting recommendations. The Montana Fish Wildlife and Parks requested the City of Helena provide maintenance flow in the Tenmile Creek drainage for preservation of trout. This Chapter provides an evaluation of the City's ability to provide the requested maintenance flow. In addition, the Tenmile Water Treatment Plant was evaluated for optimization of copper and zinc removal in order to reduce the water systems contribution of these metals to the wastewater treatment plant

Comprehensive Performance Evaluation Summary

The CPE includes a comparison of each of the City's water treatment plant's current performance to optimized performance. The objective of the CPE was to provide plant staff and administrators a prioritized list of items limiting optimized performance. Optimizing water treatment plant performance to improve the physical removal of particles is an important strategy against contamination by pathogenic microorganisms such as *Cryptosporidium* and *Giardia lamblia.* Following is a summary of optimized performance goals that were compared to current plant performance:

Minimum Data Monitoring Requirements

- Daily raw water turbidity
- Settled water turbidity at 4-hour time increments from each sedimentation basin (continuous monitoring of each basin is preferred)
- On-line (continuous) turbidity from each filter
- One hour backwash profile each month from each filter

Individual Sedimentation Basin Performance Goals

- Settled water turbidity less than 2 NTU 95 percent of the time if raw water turbidity is greater than 10 NTU, or
- Settled water turbidity less than 1 NTU 95 percent of the time if raw water turbidity is less than or equal to 10 NTU

Individual Filter Performance Goals

- Filtered water turbidity less than 0.10 NTU (excluding 15-minute period following backwashes)
- Maximum filtered water measurement of 0.30 NTU

- Initiate filter backwash immediately after turbidity breakthrough has been observed and before effluent turbidity exceeds 0.10 NTU
- Maximum filtered water turbidity following backwash of 0.30 NTU
- Maximum backwash recovery period of 15 minutes (i.e. , return to less than 0.10 NTU)
- Maximum filtered water measurement of less than 10 particles (in greater than 2 micron range) per milliliter (if particle counters are available)

Disinfection Performance Criteria

- CT values to achieve required log inactivation of Giardia and viruses 100 percent of the time.

The CPE was not performed in response to any known or anticipated compliance problems. The CPE evaluated the city of Helena's two water treatment plants' performance against optimization goals listed above that are more stringent and protective of public health than the current regulatory requirements.

Tenmile Water Treatment Plant

Source water for the Tenmile Water Treatment Plant is primarily surface water from the Tenmile watershed. A schematic of the Tenmile raw water system is provided by Figure 5-1 below. Raw water entering the plant is dosed with alum and is then screened prior to flowing through a single pipeline and flow meter to rapid mix. The flow meter cannot measure quantities under 2.8 MGD, and if the flows get below this point, the plant shuts down. The water can be dosed with chemicals including polymers, caustic soda, and chorine just prior to an inline blender-type rapid mixer. Water continues on from rapid mix to contact adsorption clarification and then to dual media filtration. Water can be dosed with activated carbon/or polymer (filter aid) prior to the filters. Filtered water is chlorinated and discharged to a small wet well directly under the plant. The water then flows by gravity to a clearwell located adjacent the plant then to the City's distribution system. The distance from the clearwell to the first customer is approximately 6 miles.

A filter backwash evaluation was completed for Filter 3. During the evaluation, samples of the spent filter backwash water were collected at one-minute intervals. The turbidity of each sample was then measured. As a rule of thumb, backwashing procedures are likely to be adequate and filter considered optimally clean when the spent backwash water turbidity is in the range of 10-15 NTU (Kawamura, 2000). The evaluation showed that backwash occurred for just over eight minutes with the turbidity of spent filter backwash water at 10 NTU. This indicates that the time of backwash is likely optimized.

During the backwash testing, the filter expansion was measured at 5 inches or about 14 percent. Backwash filter expansion is generally recommended to bin the 20-25 percent range to adequately clean the media.

Missouri River Water Treatment Plant

Source water for the Missouri River Water Treatment Plant originates at Canyon Ferry Reservoir. Water is pumped from the reservoir to a canal where it flows by gravity to a regulating reservoir. Water then flows from the regulating reservoir to the Missouri River Water Treatment Plant through a 3.5 mile long,

30-inch pipe. The reservoir has algal growth that occurs during the late summer and fall impacting treatability of the water and resulting in taste and odor. The city has the ability to add an oxidant (sodium permanganate) in the discharge line from the regulating reservoir, however; it is not used due to manganese issues in the distribution system.

Flow into the plant is controlled by a motor actuated butterfly valve. The valve is reported to be problematic and hinders precise flow control. Alum and cationic polymer are used as coagulants and are injected into the influent line ahead of a flash mixer. Water then flows through a manually cleaned fine screen and is then split between two covered flocculation basins. Flow from the flocculators discharges into a channel that delivers the flow to sedimentation basins equipped with tube settlers. Settled water flows from the sedimentation basins to eight dual media filters. Filtered water flows into a common filter clearwell where it is chlorinated and delivered by gravity to a small baffled filter clearwell and into a transfer pump wet well. Transfer pumps pump the chlorinated water to a 1.6 million gallon above-ground clearwell. Water then flows by gravity to High Zone and Low Zone pumping stations where disinfection can be added and water delivered to the City's distribution system.

An evaluation of the Missouri River Water Treatment Plant's major unit processes was performed. The adequacy of each major unit process was assessed by comparing its treatment capability to the rated peak instantaneous flow rate through the plant (12 MGD). Major unit process capability were projected based on each unit's physical size and configuration, the CPE team's experience with similar processes, industry guidelines, raw water quality, the plant's past performance, and generally accepted design standards. Table 5-1 provides a summary of major process unit performance and assumptions.

Table 5-1 - Major Process Unit Performance Summary

Unit Process	Assumptions/Design Criteria	Rated Capacity (MGD)
Flocculation	Two stage process	18.1
	20 minute hydraulic detention time	
	Variable mixing intensity	
	Visible (uncovered)	
Sedimentation	Rated at maximum filter capacity	15.6
	Rated for particle removal. Removal of TOC and color, if necessary, could be problematic	
Filters	Rated at 5 gpm/ft^2 surface loading rate	15.6
Disinfection	pH $\leq$ 8.0	14.9
	Water temperature $\geq$ 0.5 deg C	
	Minimum depth in above-ground clearwell at 15 feet	
	Free chlorine residual $\geq$ 1.0 mg/L	
	0.5 baffling factor approved by MDEQ	
	Log inactivation required = 0.5 (2.3 log removal credit granted by MDEQ)	

As can be seen in the summary provided by Table 5-1, there are no major unit process design factors that would prevent the MRWTP form meeting the optimization goals.

Based on records submitted to the evaluation team, an assessment of 2009 performance at the Missouri River Water Treatment Plant was conducted to identify whether specific treatment unit processes were performing as intended. There was insufficient data to generate a definitive assessment of plant performance toward the optimization goals. However, since the filters are placed back in service at 0.25 NTU the plant does not meet the optimization goals.

A physical examination of Filter 3 was conducted. The physical examination included probing and excavating filter media. Based on what could be seen, the filter is fully expanded during backwash and the anthracite and sand layers are re-stratified. The sand and anthracite media is clean and in good condition.

A filter backwash evaluation was completed for Filter 3. During the evaluation, samples of the spent filter backwash water were collected at one-minute intervals. The turbidity of each sample was then measured. The evaluation showed that backwash occurred for just 6.5 minutes with the turbidity of spent filter backwash water below 15 NTU after only three minutes. This indicates that the remaining three minutes of backwash was unnecessary and, quite possibly, counter-productive.

During the backwash testing, the filter expansion was measured at 8 inches or about 21 percent. Backwash filter expansion is generally recommended to be in the 20-25 percent range to adequately clean the media.

Performance Limiting Factors

The areas of design, operation, maintenance, and administration were evaluated in order to identify factors that limit performance. Factors identified as limiting performance were then classified as A, B, or C according to the following guidelines:

A – Those having a major effect on performance on a long-term, repetitive basis.

B – Those having a moderate effect on performance on a routine basis, or major effect on a periodic basis.

C – Those having only a minor effect on performance.

The CPE reported the two plants, in general, to be performing better than the regulatory requirements but are not optimized. Three A factors, five B factors and one C factor were identified. The following text is a direct reflection of the performance limiting factors reported in the CPE followed by a summary of recommendations for each provided in a separate memorandum from Crazy Mountain Services, LLC and South Hills Consulting, LLP dated October 22, 2009.

1. A Factor – Administration: Policies

The City has not adopted clear, objective and measureable goals for finished water quality. Plant operators have their own informal and unwritten public health goals that are clearly more stringent and

protective of public health than the current drinking water regulations; however measurable optimization goals have not been formally adopted. In spite of the lack of clearly defined targets, both plants perform very well. However, adoption of higher finished water standards that are both objective and measureable will provide public health benefits and may reduce costs by providing better efficiencies.

Recommendation:

- The administration and plant staff should jointly develop a written policy that clearly outlines the goals for high quality finished water.
- Commit resources necessary to achieve the goals.
- Goals should be established to maximize public health protection and be clearly identified, objective and measurable.
- Goals should be communicated to all involved parties, posted for viewing, and strived for with coordinated effort.

2. A Factor – Administration: Staffing; Number and Coverage

The City of Helena's water system is complex and extensive, and much of it is aged. In our opinion, staffing is inadequate. This is particularly true in the summer when both plants are operating. The existing staff is capable of operating both plants and repairing most equipment as it fails. However, manpower is not sufficient to keep up with preventative maintenance activities or to engage in the activities essential to achieve optimization and operational efficiencies.

- Jar testing
    - Coagulants
    - Combinations of coagulants
    - pH adjustment
- Flow splitting
- Reduction of short-circuiting

Recommendation:

- Provide funding to increase the staff by at least two full-time employees.
- Dedicate one of the new positions to preventative and corrective maintenance activities in order to reduce equipment failures, minimize chemical and energy use, and provide operators with more time for engaging in process control activities.

3. A Factor – Operation: Application of Water Treatment Concepts

The operators do not fully apply their knowledge of water treatment (see #2 above and #4 below).

- Jar testing is not used to experiment with coagulants, coagulant and flocculant aids, addition of bentonite, and variable pH conditions in efforts to handle difficult-to-treat raw water.
- Chemicals are not dosed precisely based on results of jar testing or zeta measurements.
    - More of a "seat-of-the-pants" approach.
    - 50 mg/L at the MRWTP.

- There isn't a formal filter surveillance program.
    - Media expansion is not regularly measured.
    - Spent filter backwash water turbidity is not measured and the results used to make backwash adjustments.
    - CT is not well understood.
- The backwashing procedure at the MRTP is likely not as efficient or effective as it could be.

Recommendation:

- Develop jar testing proficiency.
- Utilize jar testing to optimize the use of coagulants and coagulant aids.
- Install Zeta meters.
- Implement a filter surveillance and assessment program.
- Further evaluate media expansion deficiencies at the Tenmile Water Treatment Plant.

4. B Factor – Operation : Training Program

The operators are able to get enough continuing education credits to maintain certification. However, it is difficult to get enough "surface water treatment plant specific" training to enable everyone to become proficient in the art/science of coagulation control. Staff numbers likely contribute to the problem.

Recommendation:

- Provide additional "refresher" training and technical assistance regarding filter surveillance and coagulation control.

5. B Factor – Operation: Operational Guidelines and Procedures

The lack of written standard operating procedures leads to inconsistency in operating the two water treatment plants.

- There are two (or more) trains of thought in terms of how the plants should be operated.
- Reporting and logging are inconsistent.

Recommendation:

- Develop standard operating procedures (SOP's) for backwashing, jar testing, calibration of chemical feeders, chemical dose calculations, chemical dose changes, etc.

6. B Factor – Design: Process Controllability (primarily at MRWTP)

- Flow rates can be controlled through the sedimentation basins but can't be measured. This is likely to lead to short-circuiting and certainly makes achievement of optimal flow splitting difficult or impossible.
- The flocculators' mixers have only two speeds. With better speed control, floc formation can be better controlled.
- All flocculators and the single biggest sedimentation basin are covered so the processes cannot be observed by the operators.
    - Floc formation
    - Short-circuiting

    - Effectiveness of a flocculant aid
- Flow measurement at the head of the plant is inaccurate.
- The flow rate can be difficult to control at the head of the plant.
- Raw water pH cannot be adjusted downward with acid.
- The potassium permanganate feed rate cannot be controlled from the WTP.

Recommendation:

- Install flow measurement through the sedimentation basins.
- Provide variable speed control of flocculators'.
- Remove covers from flocculators and sedimentation basins.
- Improve MRWTP flow measurement.
- Install the ability to adjust pH downward through acid addition.
- Install potassium permanganate feed rate control at the MRWTP intake.

7. B Factor – Design: Process Instrumentation/Automation (at MRWTP)

The MRWTP is not fully automated and is not equipped with an adequate SCADA system.

- Chemical feed pumps have to be turned on and off manually.
- The SCADA system will trend turbidity but not:
    - pH
    - Filter head loss
    - Chemical feed rates/dosages
    - Filtration rates
- Backwash is not fully automated.

Recommendation:

- Install up-to-date SCADA system at he MRWTP.

8. B Factor – Design: flash Mix (at MRWTP)

The flash mixer at the MRWTP has been out of service for years. This likely makes little difference when operating in the sweep floc mode (e.g., at 50 mg/L alum), but it makes the use of charge neutralization impractical.

Recommendation:

- Repair flash mixer or install new flash mixing at the MRWTP.

9. C Factor – Maintenance: Preventative Maintenance

Preventative maintenance activities suffer due to lack of manpower. This is especially true in the summer with both plants in operation.

Recommendation:

- Utilize the city's computer maintenance management software, JOB Cal, to enhance the preventative and corrective maintenance program.

Tenmile Maintenance Flow Evaluation

The Montana Fish Wildlife and Parks requested the City of Helena provide maintenance flow in the Tenmile Creek drainage for preservation of trout. The Tenmile Creek drainage provides the raw water supply for the Tenmile Water Treatment Plant. Tenmile Creek is fed by six main tributaries including Walker Creek, Moose Creek, Minnehaha Creek, Beaver Creek, Banner, Creek and Ruby Creek. There are two reservoirs in the drainage including Scott Reservoir and Chessman Reservoir. Water is collected through a series of diversions, flumes, and buried pipes. Figure 5-1 provides a schematic of the drainage showing the location of the tributaries, reservoirs, diversions, pipes, flumes, and gaging stations.

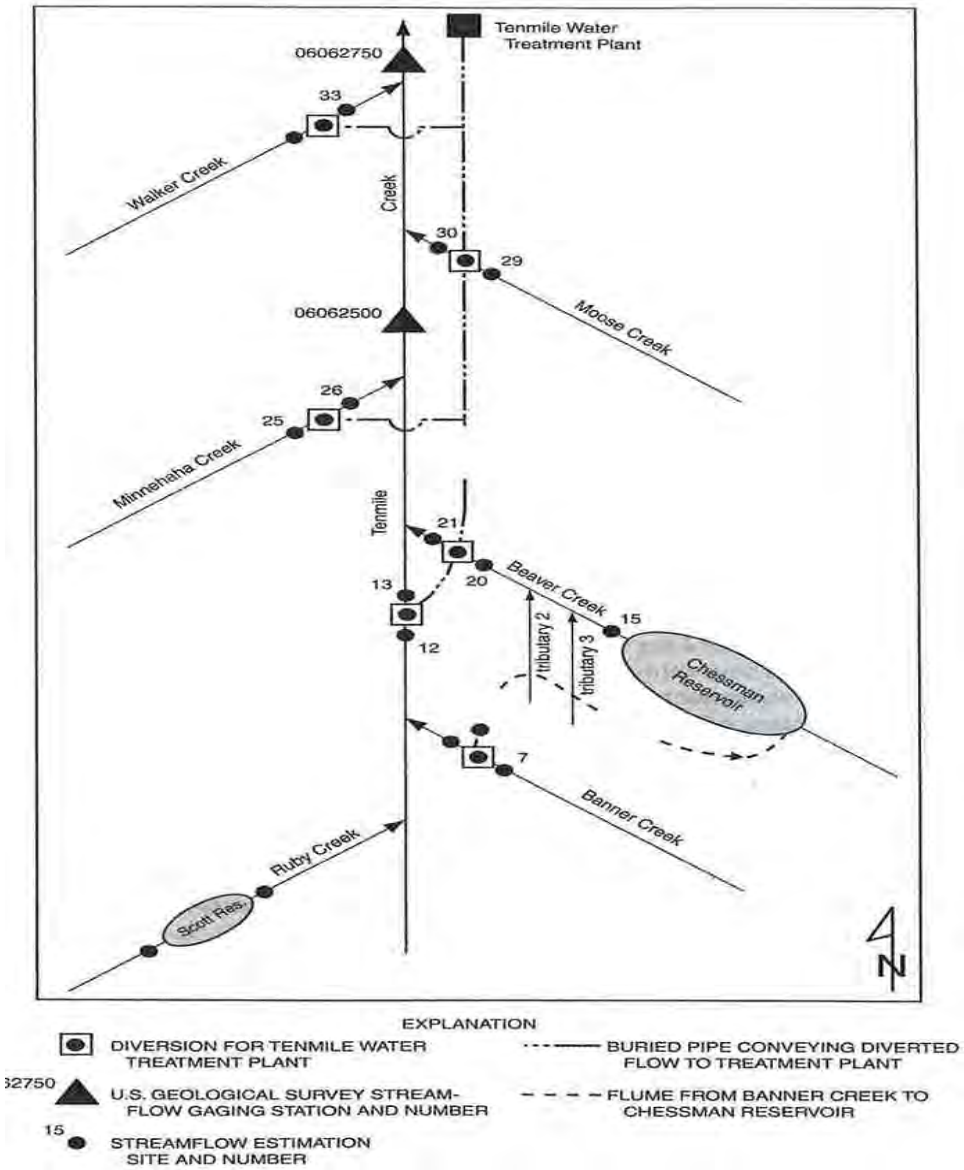

Figure 5-1 - Tenmile Drainage Schematic

The Tenmile Creek drainage supply capacity was evaluated against current and future demand to determine the level of its ability to meet an in stream maintenance flow of 1 CFS and 4 CFS. Historical data from year 2000 to year 2009 including Tenmile Treatment Plant influent flow, Tenmile Ceek flow at

the Rimini gaging station, Tenmile Creek flow near the TMTP, actual peak day demand, TMTP capacity and MRTP capacity were evaluated to determine if the City could have maintained 1 CFS and 4 CFS in Tenmile Creek under actual conditions. The evaluation showed that a 1 CFS maintenance flow could not have been maintained during the peak day demand in August of 2000 and August of 2003. A 4 CFS maintenance flow could not have been maintained during the peak day demand in July, August, and September of 2000; August and September of 2001; September of 2002; July, August and September of 2003; August of 2004; August of 2006; and August of 2007. The evaluation showed that, on the average for the period evaluated, a 1 CFS maintenance flow could have been maintained. A 4 CFS maintenance flow could have been maintained with the exception of the month of August. This determination assumes that the MRTP could be operated at a capacity of 13.9 CFS (9 MGD) and additional water could not be released from either Chessman or Scott reservoirs during the peak day demand period.

The predicted 2025 peak day demand is 32.5 CFS (21.0 MGD). If this peak day demand value is utilized in the evaluation, the system could not maintain a 1 CFS or a 4 CFS maintenance flow on the average for the period evaluated even if the MRTP is operated at its full capacity of 20.1 CFS (13.0 MGD). This assumes that additional flow could not be released from Chessman or Scott Reservoirs during the peak day demand period.

The analysis showed that the system could likely meet a 1 CFS or a 4 CFS maintenance flow under average day demand periods.

Water Treatment Plant Copper and Zinc Analysis

Bench scale analysis was performed on Tenmile Water Treatment Plant raw water to evaluate the use of alterative polymers and coagulants for optimization of zinc, copper, and TOC removal. The goal of the analysis was to evaluate alternatives for minimizing the Tenmile's contribution of copper and zinc to the City's wastewater system. The City's MPDES discharge permit contains restrictive limits for copper and zinc.

Table 5-2 provides a summary of copper and zinc concentrations in the Tenmile Water Treatment Plant raw and finished water in comparison with MPDES discharge permit limits.

Table 5-2 - Tenmile Treatment Plant Copper and Zinc Data Summary

Sample Date	Raw Water Copper mg/L	Raw Water Zinc mg/L	Finished Water Copper mg/L	Finished Water Zinc mg/L	MPDES Discharge Permit Limits (mg/L)			
					AML Copper	MDL Copper	AML Zinc	MDL Zinc
12/8/2007	<0.001	0.195	<0.001	0.189	0.009	0.013	0.11	0.11
11/19/2008	0.0006	0.196	<0.001	0.16				
5/20/2009	<0.001	0.120	<0.001	0.100				
3/26/2010	ND	0.18						
11/29/2010			<0.001	0.272				
12/7/2010	<0.001	0.195	<0.001	0.191				
Average	**<0.001**	**0.177**	**<0.001**	**0.182**				
Max	**<0.001**	**0.196**	**<0.001**	**0.272**				

The data indicates that copper concentrations in Tenmile raw and finished water are quite low and below the average monthly and maximum daily discharge permit limits. It is unlikely that much improvement could be made by increasing copper removal at the Tenmile plant. However, raw and finished water zinc concentrations are well above the discharge permit limits. It may be possible to significantly reduce the contribution of zinc to the wastewater treatment plant by improving zinc removal at the Tenmile treatment plant.

Further evaluation of the data shows that zinc concentrations in the wastewater treatment plant effluent are the highest during the winter and spring months when the Tenmile Treatment Plant is typically the sole water source for the City. Any percentage reduction that can be achieved in Tenmile Treatment Plant effluent zinc concentration would result in a proportionate reduction in wastewater treatment plant effluent zinc concentration. The highest recorded WWTP influent zinc concentration in the last five years was 0.32 mg/L. The corresponding WWTP effluent zinc concentration was 0.02 mg/L, a 38% reduction in zinc concentration through the WWTP processes. An additional 45% reduction would be required to achieve the MPDES discharge permit requirements.

Bench Scale Analysis

TTP effluent copper concentrations are quite low and it was determined that little improvement could be made by improving copper removal at the TTP. Conversely, TTP effluent zinc concentrations are well above the MPDES discharge permit limits and it may be possible to significantly reduce the contribution of zinc to the wastewater treatment plant by improving zinc removal at the TTP.

Bench scale analysis was completed on TTP raw water samples. The analysis showed that zinc levels could be significantly reduced by raising pH and optimizing alum and polymer addition. It is recommended that full scale testing be completed at the TTP to further determine the effectiveness of zinc removal under actual field conditions.

Chapter 6: Recommended Plan

Introduction

Chapter 3 evaluated the distribution system with regard to pressure, fire flow, and water quality using the updated hydraulic model. Alternatives for addressing deficiencies were examined. Chapter 4 evaluated storage needs and pressure zones identifying potential pressure zone adjustments and locations for a Lower Malben-Woolston storage tank. Potential tank sites were evaluated in detail. In addition, the MRTP low zone and high zone pumping stations were evaluated with regard to operation with a new Lower Malben-Wooston storage tank and for optimization. Chapter 5 summarized the findings and recommended improvements from the Comprehensive Performance Evaluations for the Missouri River and Ten Mile treatment plants. The purpose of this Chapter is to summarize the findings and recommendations developed in previous chapters, prioritize recommended improvements, provide estimates of proposed project costs, and provide an implementation plan with triggers for executing improvements.

Capital Improvement Program Prioritization

The City of Helena has limited resources to invest in water infrastructure, making prioritization of capital improvement projects a necessity. Multiple criteria govern the prioritization of capital improvement projects. The following list highlights the criteria that should be considered when setting capital improvement priorities for water system improvements:

- Fire Protection
- Source Water Protection
- Protection of Public Health
- Distribution System Reliability
- Water Treatment Reliability
- Growth
- System Pressure and Flow Stabilization
- Operational Flexibility
- Coordination and Compatibility with Other Capital Programs, i.e. Street Overlays.
- Renewal and Replacement (infrastructure age and condition)
- Regulatory Compliance

Capital Improvement Recommendations

Distribution System

Analysis performed on the water system concluded that improvements are needed to the system to improve fire flow, pressure, and water quality to better serve existing customers. In addition, existing

system components must be replaced once they reach the end of their useful life. Typically, replacing about 2% of the total system per year is an adequate goal to achieve a recommenced 50-year replacement cycle. It may be more appropriate, based on current historical service life, to replace distribution system piping on a 100-year cycle, or 1% per year.

The distribution system piping analysis evaluated improvements related to redundancy, reduction in headloss, improvement to fire flow, interconnection of pressure zones and pump stations to improve operability and service, major waterline extensions and rehabilitation projects.

General System Improvements

General recommendations to improve redundancy and operability of the existing system and their associated cost are summarized in Table 6-1.

Table 6-1 - General System Improvements Summary

Description	**Estimated Cost[1]**
Connection of Winne to Hale	$636,000
Connection of Reeder's Village to West Main and Eureka	$245,000
Connection of Westside to Reeder's Village	$1,100,000
Parallel 20-inch line from MRTP near the airport	$1,500,000
Connect Winne Zone to Reeder's Village	$865,000
Parallel or replace 12-inch lines along Custer	$2,100,000
Connection of potential booster pump station from Lower Malben-Woolston Zone to Upper Malben-Woolston Zone	$600,000
Valley Zone Initiation	$29,000,000
Airport Area Interconnection	$550,000
Carter and Highway 12	$122,000
Monitoring PRVs	$184,000
Total	**$ 36,902,000**

Fire Flow Improvements

The hydraulic analysis identified many areas within the City that do not meet the minimum required fire flow under Montanan DEQ code and the proposed UFC requirements. Improvements to the system, including installation of new water mains, upsizing existing water mains, rehabilitation or replacement of old impaired pipelines and adjustment of pressure zones were evaluated with the hydraulic model to determine the best approach to improving fire flow. The main areas of fire flow related improvements included: The East Industrial/Manufacturing area in the vicinity of the airport; the West Side; Central Helena; Hale Zone; Carroll College; and the area in the vicinity of the railroad tracks. Recommended fire flow improvements and their associated costs are summarized in Table 6-2.

Table 6-2 - Summary of Recommended Fire Flow Improvements

Area	Project	Length, LF	Estimated Cost[1]
East Industrial	Airport Road	3,435	$772,990
	Armor Metals	172	$34,320
	Centennial Drive	6,605	$1,477,310
	Walnut Street	5,343	$1,170,570
	East Industrial Total	**15,555**	**$3,455,190**
West Side	Allison St	3,365	$637,970
	Choteau	342	$68,340
	Cruse Ave Crossing	771	$154,320
	Euclid Alley	171	$28,270
	Euclid Henderson	806	$181,320
	Garfield	1,771	$352,890
	Gant St	6,363	$1,173,110
	Hauser	5,277	$1,187,340
	Leslie Ave	446	$89,150
	Mountain View	3,674	$700,860
	Park Ave Tie-in	312	$62,430
	Wilder	4,924	$976,730
	West Side Total	**28,223**	**$5,612,730**
Central Helena	Aspen St E	961	$192,190
	Chestnut St W	1,423	$284,610
	Cole Ave E	1,938	$399,650
	Columbia Ave	2,384	$475,760
	Elm St E	1,515	$301,870
	Front St Improvements	2,453	$486,530
	Gold Ave Phase I	2,150	$383,860
	Gold Ave Phase II	1,575	$296,400
	Jackson Logan Rehab	1,960	$389,920
	Lamborn/Poplar/Oakes	2,262	$450,640
	Lyndale West	2,855	$567,690
	Misc Hydrant Laterals	11	$2,120
	Montana Ave Phase I	2,206	$489,950
	Montana Ave Phase II	2,405	$529,050

Area	Project	Length, LF	Estimated Cost[1]
	N Cooke St	2,808	$461,130
	N Harris St	2,562	$573,550
	National/Dodge/Phoenix W	2,049	$408,660
	Orange Ave E	1,667	$370,850
	Orange Ave W	2,051	$458,590
	Poplar St E	1,948	$436,230
	Poplar St W	2,391	$516,050
	Sanders St	778	$165,820
	Central Helena Total	**42,354**	**$8,741,120**
Hale Zone	3rd St	1,787	$357,520
	Beattie	2,108	$463,210
	Blake St	416	$83,280
	Chaucer	1,696	$338,760
	Cutler/Ewing	781	$157,980
	Highland	1,891	$378,290
	Hillsdale St	4,241	$848,360
	Miller	717	$143,370
	Misc Hydrant Laterals	11	$1,750
	Pine	1,160	$249,670
	Rhode Island, 1st and 2nd	2,308	$465,210
	S Davis Improvements	592	$118,520
	Soencer/Rodney	3,090	$642,320
	State St	3,120	$646,640
	West Main Improvements	3,576	$715,090
	Hale Zone Total	**27,495**	**$5,609,970**
Carroll College		**5,525**	**$1,194,860**
Area in Vicinity of Railroad Tracks		**7,235**	**$1,471,840**
Total		**126,385 (24 miles)**	**$ 26,085,710**

Each individual fire flow improvement project listed in Table 6-2 was evaluated and scored based on age, percentage of model nodes not meeting fire flow requirements, and pipe breaks. The projects were then prioritized according to their score, the higher the score the higher the priority. Table 6-3 lists the projects according to priority score.

Table 6-3 - Fire Flow Improvement Project Priority Scoring

Project Name	Project Area	Length, LF	Project Cost	Project Score
Front St Improvements	Central Helena	2,453	$486,530	15
Chesnut St W	Central Helena	1,423	$284,610	14
Jackson Logan Rehab	Central Helena	1,960	$389,920	14

Project Name	Project Area	Length, LF	Project Cost	Project Score
Misc Hydrant Laterals	Central Helena	11	$2,120	14
National/Dodge/Phoenix W	Central Helena	2,049	$408,660	14
Armor Metals	East Industrial	172	$34,320	13
Misc Hydrant Laterals	Hale Zone	11	$1,750	13
Blake St	Hale Zone	416	$83,280	12
Choteau	West Side Improvements	342	$68,340	12
Lyndale West	Central Helena	2,855	$567,690	12
Railroad	Railroad	7,235	$1,400,000	12
S Davis Improvements	Hale Zone	592	$118,520	12
State St	Hale Zone	3,120	$646,640	12
3rd St	Hale Zone	1,787	$357,520	11
Euclid Alley	West Side Improvements	171	$28,270	11
Gold Ave Phase II	Central Helena	1,575	$296,400	11
Leslie Ave	West Side Improvements	446	$89,150	11
Park Ave Tie-In	West Side Improvements	312	$62,430	11
Pine	Hale Zone	1,160	$249,670	11
West Main Improvements	Hale Zone	3,576	$715,090	11
Allison St	West Side Improvements	3,365	$637,970	10
Aspen St E	Central Helena	961	$192,190	10
Beattie	Hale Zone	2,108	$463,210	10
Chaucer	Hale Zone	1,696	$338,760	10
Cole Ave E	Central Helena	1,938	$399,650	10
Columbia Ave	Central Helena	2,384	$475,760	10
Cutler/Ewing	Hale Zone	781	$157,980	10
Euclid Henderson	West Side Improvements	806	$181,320	10
Grant St	West Side Improvements	6,363	$1,173,110	10
Miller	Hale Zone	717	$143,370	10
Montana Ave Phase I	Central Helena	2,206	$489,950	10
Mountain View	West Side Improvements	3,674	$700,860	10
Orange Ave E	Central Helena	1,667	$370,850	10
Poplar St W	Central Helena	2,391	$516,050	10
Spencer/Rodney	Hale Zone	3,090	$642,320	10
Wilder	West Side Improvements	4,924	$976,730	10
Carroll College	Carroll College	5,500	$1,200,000	9
Cruse Ave Crossing	West Side Improvements	771	$154,320	9
Garfield	West Side Improvements	1,771	$352,890	9
Hauser	West Side Improvements	5,277	$1,187,340	9
Highland	Hale Zone	1,891	$378,290	9
Hillsdale St	Hale Zone	4,241	$848,360	9
Rhode Island, 1st And 2nd	Hale Zone	2,308	$465,210	9

Project Name	Project Area	Length, LF	Project Cost	Project Score
Walnut St	East Industrial	5,343	$1,170,570	9
Airport Road	East Industrial	3,435	$772,990	8
Centennial Drive	East Industrial	6,605	$1,477,310	8
Elm St E	Central Helena	1,515	$301,870	8
Lamborn/Poplar/Oakes	Central Helena	2,262	$450,640	8
Montana Ave Phase II	Central Helena	2,405	$529,050	8
N Cooke St	Central Helena	2,808	$561,130	8
Orange Ave W	Central Helena	2,051	$458,590	8
Poplar St E	Central Helena	1,948	$436,230	8
Gold Ave Phase I	Central Helena	2,150	$383,860	6
N Harris St	Central Helena	2,562	$573,550	6
Sanders St	Central Helena	778	$165,820	6

Tenmile Transmission Main

The Tenmile transmission main cannot currently convey the total capacity of the Tenmile Water Treatment Plant to the City of Helena water distribution system. In addition, parts of the existing main are old and failing. Alternatives for renewal and replacement and capacity expansion were evaluated and it is recommended that the older segments of pipe from the TTP to the control valve and from the end of the existing 36-inch ductile iron pipe to town be replaced with a new 36-inch ductile iron main. The costs of these projects are summarized in Table 6-4.

Table 6-4 - Tenmile Transmission Main Cost Summary

Description	Estimated Cost
36-inch main from TTP to control valve	$2,665,000
36-inch main from end of existing 36-inch to Town	$1,726,000
Total	**$ 4,391,000**

Pressure Zones and Storage

Lower Malben-Wooston Storage Tank

The Lower Malben-Woolston (Lower Zone) and Valley Zones need 4.03 MG of storage to meet projected 2025 demands if the excess capacity of the Upper Malben-Woolston Zone (Upper Zone) is taken into consideration. The storage requirements of these zones can be met by either improving storage capacity in the Upper Zone or by constructing new storage in the Lower and Valley Zones or a combination of both. Constructing improvements to the TTP backwash and surface wash pumping facilities would maximize clearwell storage volume and add 1.1 MG of storage to the system, reducing the required

Lower and Valley Zone storage volume to 2.93 MG. This project however, would not improve low zone pressure conditions or reduce energy costs associated with low zone pumping.

The Lower zone tank evaluation concluded that constructing a tank at the Batch Fields, I-15, and Henderson sites are all viable options with the Batch Fields and I-15 sites ranking the highest when all parameters were considered. Constructing a low zone tank would significantly reduce low zone system pressures and provide some energy savings.

Growth has slowed considerably in the Helena valley since the 2005 Water Facility Plan was completed and the demand projections for 2025 were made. It is reasonable to believe that the 2025 demand projections may not be realized until sometime beyond 2025. Taking the current economy and growth rates into consideration, it is recommended that the City consider building two 1.5 MG tanks instead of a single 3.0 MG tank. The analysis shows that additional storage will be required by approximately 2016 under the current growth projections. A 1.5 MG tank would provide adequate capacity until approximately 2025 if the Valley Zone does not grow and connect to the City's system. The City should continue to assess development patterns and property availability as a decision is made as to the best location and size of the Low Zone tank. Table 6-5 summarizes the cost of the Batch Fields and I-15 tank alternatives if a 1.5 MG tank is constructed.

Table 6-5 – Low Zone Reservoir Cost Summary

Project Element	Batch Fields	I-15
Tank	$2,860,000	$1,500,000
LZ to HZ Booster Pumping	N/A	$800,000
MRTP HZ Pumping Modifications	N/A	$50,000
Connector Piping	$100,000	$1,110,000
Base Project Cost	**$2,960,000**	**$3,460,000**
Pipe Optimization	$3,200,000	$2,900,000
West Side LZ to HZ Booster PS	$600,000	$800,000
Total Project Cost	**$6,760,000**	**$7,160,000**

It should be noted that development in the area of the I-15 tank location could provide the opportunity for a portion of the interconnecting piping cost to be shared by development.

Woolston Tank Optimization

It would be inefficient to invest money into the Woolston tanks to improve storage capacity since the deficiency in storage is in the Lower Malben-Woolston and Valley Zones. As shown by the storage evaluation in Chapter 4 the Woolston tanks do not contribute to the overall usable storage volume for the Upper and Lower Zones. The Woolston tanks do contribute to emergency storage, however; since water does not cycle through the tanks under normal hydraulic conditions, water quality is an issue. If improvements are made to the TTP so that the usable clearwell volume is increased, the need for emergency storage from the Woolston tanks could be minimized and they could be taken out of service.

Malben

Similarly to the Woolston Tanks, it would be inefficient to invest money into the Malben Reservoir to add storage capacity for the Lower Zone. The cost of constructing a new Dalhausen Pumps Station is estimated to be $1.2 million. It is not recommended that a new Dalhausen Pump Station be constructed at this time simply to provide additional storage to the Lower Zone. It is recommended that backup power be installed and pump capacity improvements be made to the Dalhausen Pump Station to better serve peak hour demands for the Winne Zone.

Hale

Based on production records and information provided by the City, the Eureka source has a difficult time keeping up with demands during peak demand periods and an alternative source for the Hale and Upper Hale zones should be provided. It is recommended that the Hale Zones be connected to the Upper Malben-Woolston zone and Reeder's Village. The costs of these projects are included in Table 6-1 - above.

Westside

Although improvements have been made to improve operation of the Westside tank, water quality is still an issue. It is recommended that the pressure zone be connected to Reeder's Village to increase demand and improve water quality. The cost associated with this improvement is included in Table 6-1 - above.

Fort Harrison

Under maximum day demands operating the MRTP alone does not provide sufficient head to keep the Fort Harrison tank full. A booster pump station will be required to maintain sufficient enough pressure to fill the Fort Harrison Tank. At current maximum day demands, flows require a 20-30' boost. At 2025 maximum day demands and only the MRTP operating, a boost of 65' will be necessary.

- Since the TTP provides plenty of head to supply the system, a bypass should be installed as part of the booster pumping station with a PRV to reduce pressures to the Fort Harrison tank overflow hydraulic grade line and minimize booster pumping.

Additionally, the backflow preventer and master meter for the entire system could be relocated to a central location (in the booster pump station).

It should be noted that the cost of constructing a Fort Harrison Pumping Station and piping improvements should be paid by Fort Harrison.

Lower Malben-Woolston Pumping

The Lower Zone Pumping Station would operate more efficiently and be better utilized with construction of a Lower Zone storage tank. A tank would eliminate pumping into a closed system and a hydraulic grade line would be established based on the reservoir water elevation. Considering it could take several years to construct a Low Zone tank and the lower Zone Pumping system would need to operate as it does now when the tank is taken out of service for maintenance, it is recommended that the Lower Zone Pumping Station be improved. If a variable frequency drive (VFD) is installed on the

small pump and the three pump system is programmed to operate to maintain a pressure setpoint, recycle of water back to the clearwell could be eliminated and water feeding the Low Zone from the Upper Zone during MRTP operation could be greatly reduced. It is recommended that the City implement these improvements in the near term prior to construction of the recommended Low Zone tank.

Summary of Recommendations

Recommendations for capital projects to improve the City's water system were split into two categories. The first category, summarized in Table 6-6, includes storage, transmission, and pumping system improvements that are required to modify the pressure zones to improve system pressure conditions, meet storage demand, and provide reliable transmission of drinking water throughout the system. The second category, summarized in Table 6-7, includes renewal and replacement and fire flow improvement projects. Projects are shown in order of priority, however; the City should continue to assess priorities on at least an annual basis and adjust as necessary.

Table 6-6 - Summary of Recommended Storage, Transmission, and Pumping Capital Projects

Project	Project Type	Rank	Triggers	Estimate of Probable Project Cost
Lower Malben-Woolston Zone Pumping Improvements	Pumping Optimization and Pressure Improvement	4	High pressure spikes	$50,000
Lower Malben-Woolston Zone Tank and Connector Piping	Storage, Distribution and Pressure Zone Optimization	1	Growth, pressure zone improvement to reduce system failures	$3,460,000
36-inch main from TTP to control valve	Transmission Rehabilitation	3	System failure, growth and need for capacity improvement	$2,665,000
36-inch main from end of existing 36-inch to Town	Transmission Rehabilitation	2	System failure, growth and need for capacity improvement	$1,726,000
Lower Malben-Woolston Pumping Station (West Side)	Water Quality and Distribution Improvement	5	Water quality and system reliability	$600,000
Benton and Custer Pipe Upsize (Tank Optimization)	Distribution Optimization	6	Water quality and system reliability	$3,200,000
Dalhausen Pump Station	Pumping	9	System failure	$150,000

Project	Project Type	Rank	Triggers	Estimate of Probable Project Cost
Improvements	Reliability			
Ten Mile Water Treatment Plant Backwash/Surface Wash Pumping Improvements	Storage Optimization	10	Growth	$240,000
Connect Airport to Low Zone	Distribution Optimization	7	Pressure zone improvement	$450,000
Carter & Highway 12	Distribution Optimization	8	Pressure zone improvement	$100,000
PRV Telemetry	Distribution Optimization	19	Pressure zone improvement	$150,000
Paralleling The 20-inch MRTP Discharge	Distribution Optimization	17	Growth, system reliability	$1,200,000
Paralleling The 24-inch MRTP Discharge	Distribution Optimization	18	Growth, system reliability	$1,080,000
Connect Forest Estates to Reader's Village	Distribution Optimization	12	System reliability and demand	$910,000
Connect Hale Zone to Winne Zone	Distribution Optimization	14	System reliability and demand	$520,000
Southwest Piping Improvements	Distribution Optimization	13	System reliability and demand	$4,400,000
Hale Zone Piping Improvements	Distribution Optimization	15	System reliability and demand	$3,400,000
Connect West main to Reeder's Village, Upsize Piping, Connect Reeder's to Hale	Distribution Optimization	11	System reliability and demand	$200,000
Connect Winne Zone to Reeder's Village	Distribution Optimization	16	System reliability and demand	$500,000
Fort Harrison booster pumping	Distribution Reliability	20	System reliability and demand	$800,000

Table 6-7 - Recommended Renewal and Replacement/Fire Flow Improvement Capital Projects

Project	Project Type	Priority Score (0 - 20, 20 = highest)	Service Area	Triggers	Estimate of Probable Project Cost
Front St Improvements	Fire Flow Improvements	15	Central Helena	Pipe Failure, Street Improve ments	$486,530
Chesnut St W	Fire Flow Improvements	14	Central Helena	Pipe Failure, Street Improve ments	$284,610
Jackson Logan Rehab	Fire Flow Improvements	14	Central Helena	Pipe Failure Street Improve ments	$389,920
Misc Hydrant Laterals	Fire Flow Improvements	14	Central Helena	Pipe Failure Street Improve ments	$2,120
National/Dodge/Phoenix W	Fire Flow Improvements	14	Central Helena	Pipe Failure Street Improve ments	$408,660
Armor Metals	Fire Flow Improvements	13	East Industrial	Pipe Failure Street Improve ments	$34,320
Misc Hydrant Laterals	Fire Flow Improvements	13	Hale Zone	Pipe	$1,750

Project	Project Type	Priority Score (0 - 20, 20 = highest)	Service Area	Triggers	Estimate of Probable Project Cost
				Failure Street Improve ments	
Blake St	Fire Flow Improvements	12	Hale Zone	Pipe Failure Street Improve ments	$83,280
Choteau	Fire Flow Improvements	12	West Side Improvements	Pipe Failure Street Improve ments	$68,340
Lyndale West	Fire Flow Improvements	12	Central Helena	Pipe Failure Street Improve ments	$567,690
Railroad	Fire Flow Improvements	12	Railroad	Pipe Failure Street Improve ments	$1,400,000
S Davis Improvements	Fire Flow Improvements	12	Hale Zone	Pipe Failure Street Improve ments	$118,520
State St	Fire Flow Improvements	12	Hale Zone	Pipe Failure	$646,640

Project	Project Type	Priority Score (0 - 20, 20 = highest)	Service Area	Triggers	Estimate of Probable Project Cost
				Street Improve ments	
3rd St	Fire Flow Improvements	11	Hale Zone	Pipe Failure Street Improve ments	$357,520
Euclid Alley	Fire Flow Improvements	11	West Side Improvements	Pipe Failure Street Improve ments	$28,270
Gold Ave Phase II	Fire Flow Improvements	11	Central Helena	Pipe Failure Street Improve ments	$296,400
Leslie Ave	Fire Flow Improvements	11	West Side Improvements	Pipe Failure Street Improve ments	$89,150
Park Ave Tie-In	Fire Flow Improvements	11	West Side Improvements	Pipe Failure Street Improve ments	$62,430
Pine	Fire Flow Improvements	11	Hale Zone	Pipe Failure Street	$249,670

Project	Project Type	Priority Score (0 - 20, 20 = highest)	Service Area	Triggers	Estimate of Probable Project Cost
				Improve ments	
West Main Improvements	Fire Flow Improvements	11	Hale Zone	Pipe Failure Street Improve ments	$715,090
Allison St	Fire Flow Improvements	10	West Side Improvements	Pipe Failure Street Improve ments	$637,970
Aspen St E	Fire Flow Improvements	10	Central Helena	Pipe Failure Street Improve ments	$192,190
Beattie	Fire Flow Improvements	10	Hale Zone	Pipe Failure Street Improve ments	$463,210
Chaucer	Fire Flow Improvements	10	Hale Zone	Pipe Failure Street Improve ments	$338,760
Cole Ave E	Fire Flow Improvements	10	Central Helena	Pipe Failure Street Improve	$399,650

Project	Project Type	Priority Score (0 - 20, 20 = highest)	Service Area	Triggers	Estimate of Probable Project Cost
				ments	
Columbia Ave	Fire Flow Improvements	10	Central Helena	Pipe Failure Street Improve ments	$475,760
Cutler/Ewing	Fire Flow Improvements	10	Hale Zone	Pipe Failure Street Improve ments	$157,980
Euclid Henderson	Fire Flow Improvements	10	West Side Improvements	Pipe Failure Street Improve ments	$181,320
Grant St	Fire Flow Improvements	10	West Side Improvements	Pipe Failure Street Improve ments	$1,173,110
Miller	Fire Flow Improvements	10	Hale Zone	Pipe Failure Street Improve ments	$143,370
Montana Ave Phase I	Fire Flow Improvements	10	Central Helena	Pipe Failure	$489,950
Mountain View	Fire Flow Improvements	10	West Side Improvements	Pipe Failure	$700,860

Project	Project Type	Priority Score (0 - 20, 20 = highest)	Service Area	Triggers	Estimate of Probable Project Cost
Orange Ave E	Fire Flow Improvements	10	Central Helena	Pipe Failure	$370,850
Poplar St W	Fire Flow Improvements	10	Central Helena	Pipe Failure	$516,050
Spencer/Rodney	Fire Flow Improvements	10	Hale Zone	Pipe Failure	$642,320
Wilder	Fire Flow Improvements	10	West Side Improvements	Pipe Failure	$976,730
Carroll College	Fire Flow Improvements	9	Carroll College	Pipe Failure	$1,200,000
Cruse Ave Crossing	Fire Flow Improvements	9	West Side Improvements	Pipe Failure	$154,320
Garfield	Fire Flow Improvements	9	West Side Improvements	Pipe Failure	$352,890
Hauser	Fire Flow Improvements	9	West Side Improvements	Pipe Failure	$1,187,340
Highland	Fire Flow Improvements	9	Hale Zone	Pipe Failure	$378,290
Hillsdale St	Fire Flow Improvements	9	Hale Zone	Pipe Failure	$848,360
Rhode Island, 1st And 2nd	Fire Flow Improvements	9	Hale Zone	Pipe Failure	$465,210
Walnut St	Fire Flow Improvements	9	East Industrial	Pipe Failure	$1,170,570
Airport Road	Fire Flow Improvements	8	East Industrial	Pipe Failure	$772,990
Centennial Drive	Fire Flow	8	East Industrial	Pipe	$1,477,310

Project	Project Type	Priority Score (0 - 20, 20 = highest)	Service Area	Triggers	Estimate of Probable Project Cost
	Improvements			Failure	
Elm St E	Fire Flow Improvements	8	Central Helena	Pipe Failure	$301,870
Lamborn/Poplar/Oakes	Fire Flow Improvements	8	Central Helena	Pipe Failure	$450,640
Montana Ave Phase II	Fire Flow Improvements	8	Central Helena	Pipe Failure	$529,050
N Cooke St	Fire Flow Improvements	8	Central Helena	Pipe Failure	$561,130
Orange Ave W	Fire Flow Improvements	8	Central Helena	Pipe Failure	$458,590
Poplar St E	Fire Flow Improvements	8	Central Helena	Pipe Failure	$436,230
Gold Ave Phase I	Fire Flow Improvements	6	Central Helena	Pipe Failure	$383,860
N Harris St	Fire Flow Improvements	6	Central Helena	Pipe Failure	$573,550
Sanders St	Fire Flow Improvements	6	Central Helena	Pipe Failure	$165,820

The projects summarized in the Tables above are in order of priority considering current conditions. The City should continue to assess priorities on at least an annual basis and adjust as necessary for changing conditions.